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MARKINGS ON ARISTILLUS.

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In the May and November (1914) numbers of POPULAR ASTRONOMY appeared articles, by Professor W. H. Pickering, concerning the unusual behaviour of certain markings in the lunar crater Aristillus. Similar changes, he says, occur in markings in Autolycus, Archimedes, Plato and others. He states as his belief that the changes in the appearance of the markings are produced by vegetable growth there.

At his request Dr. Lowell and the writer have studied these markings. Our particular attention was given to the markings on the northwest wall of the crater Aristillus, although the other craters were also examined, as they were said to present the most remarkable examples of the phenomena. They were critically observed here at various phases of the moon and during different lunations.

The first observations were made on April 23, 1915 and the last on June 28. For the former date the lunar co-longitude was about 25°. Sunrise on Aristillus occurred at colongitude 1°, thus the sunlight reached the walls of Aristillus but two days prior to the time of the first observations and the shadow of the wall upon the bed of the crater had just shortened sufficiently to uncover the markings. They were already obvious at a glance. They were found to consist of a pair of divergent, dark, narrow streaks which begin on the floor of the crater, cross step-like ridges to cut the northwest rim and then descend the outer slope, gradually becoming invisible in a few miles. Within the crater both are very slightly curved toward the south (See Fig. 1). The northern one keeps about the same general direction throughout its entire length; but the southern one is broken at the rim of the crater by a distinct offset and beyond this point it leaves the other marking at a rather sharp angle as it passes down the outer slope. Inside the crater the two diverge by only a few degrees, perhaps 8° or 10°, from the origin to the rim; on the outside the divergence is much greater, about 29°. There is a visible cleft in the wall where the markings

emerge from the crater. In fact throughout their length they lie at a generally lower level than the adjoining country, and frequently appear to form the edge of elevated mesa-like regions; this is particularly true of the markings inside the crater. The inner ones were at all times darkest. Viewed as a whole the markings are not straight lines, or are they of uniform intensity; they show, rather, the broken, irregular appearance that would be expected of deep cracks partially lighted. Here and there they narrow and weaken in crossing the more brilliant places, but at the intersection of shaded spots there is a perfect blending and they widen out or grow more intense. Thus their contours are modified where they encounter shadows or partial shadows, and the two blend into one and the same thing. This often happens, and always the colors perfectly match. The shadows about the crater were of the same color and general appearance as the markings.

Many other markings of the same character as these are to be seen about the crater, mostly on the northwest wall and running in the same general direction. These, like the ones under discussion, appeared as rifts or cracks in the wall which were enhanced and brought into view by the shadows, or feeble illumination of their own walls. Not only this but other craters show markings of the precise character of these differing only in form; all apparently are shaded clefts. It is noteworthy that these markings always seem to occur on the northwest walls of the craters and to all have nearly the some position angle; that they occur on craters lying at a considerable distance from the moon's equator, all having a latitude of about 30° or more.

The sun's position with reference to Aristillus at the time of the observations.

Time of observation at Flagstaff	Altitude of ⊙ above Aristillus	Azimuth of ⊙	Direction of ⊙
April 23 8 h m M.M.	+22° 27′	+104° 19′	East 14° 19′ S
" 24 7 "	31 40	112 15	" 22 15 "
" 25 8 "	41 0	122 58	" 32 58 "
" 27 11 30 "	55 14	156 24	S 23 36 E
May 1 16 30 "	41 53	235 45	W 34 15 S
" 2 16 "	33 16	246 8	W 23 52 S
" 3 16 30 "	23 29	255 0	W 15 0 S

No indication of vegetation resulted from the observations; on the contrary everything they disclosed tended to show that the markings are natural features in the lunar surface made to stand out by unequal illumination. They appear to be mere cracks, perhaps, of great depth, which run across the floor of the crater and through the wall to taper away till they become invisible on the slope outside. The inner markings indicate this more than the outer ones. Throughout they cross very

rugged country but this only adds to the conviction that they are cracks, because it is usual for the lunar cracks to traverse plain and mountain alike, disregarding all inequalities. The fact that the markings do not exhibit any unusual color and that they so exactly match the shadows in tint favors the above belief.

If we leave out of consideration all of the known conditions adverse to life on the moon, and suppose it is just within the limit of possibility that a low form of vegetation might exist there, would it not still seem very strange to find a strip of vegetation beginning there on the floor of a crater and mounting the wall at an elevation of near 10,000 feet, an elevation almost equaling the altitude at which plant growth is limited on mountains in our temperate terrestrial climate. Add to this the extreme conditions of atmosphere and temperature that must exist on the moon, and the consequent adaptation required of vegetation at such varying altitudes, then the idea becomes incredible. Moreover the fact that the inner markings appear at practically the same moment the shadow leaves their locality, and that the markings outside disappear two or three days before sunset is strongly against the theory that they are vegetation. However, observations made at the precise time of full moon showed that these markings, which were so obvious only a few hours before, had wholly disappeared and their former place was marked in a general way by a faint bluish grey band that issued from the crater through the cleft wall to lose itself in the dusky patches outside. Not many hours after full moon this diffuse band, in turn, disappeared to give place again to the old markings. Thus the fact that they appear to grow more intense under a high sun only to fade out entirely at the hour of full moon, and to strikingly reappear not many hours later, not only precludes vegetation but at the same time obviously discloses their identity—shadowed cracks.

The dark areas or "fields" where the two markings in Aristillus are said to terminate are at no time very conspicuous. Their counterparts too, are to be seen elsewhere; in fact quite a great number are to be found scattered over the moon. They are dusky patches of a medium dark grey tone, of various sizes and forms, but otherwise they are all very similar. These dusky regions have always been seen by selenographers and are fairly marked when the moon is highly illuminated. If any photograph of the full moon be examined many of these dusky regions will be noted. It seems very likely that all these dark patches are caused by a like condition but since they cover such a large portion of the moon it can hardly be expected that they mark the existence of vegetation. They are produced, probably by differences in the nature of the surface which affect the power of reflecting the light received; and

if they increase in intensity as the sun rises higher upon them, it must be only apparent and caused by contrast effects.

It was found, too that these markings on Aristillus do not resemble the double "canals" of Mars; not only do they differ in general appearance but also in the important respect that they are not parallel. The double "canals" of Mars are parallel throughout their length; these lunar markings diverge, first by about ten degrees and then, farther along, by as much as twenty-nine degrees. However there is another, an even more potent reason why they are not comparable to either the single or double "canals". It must be remembered that they measure but a few miles in length and in actual width only a few hundred feet, therefore if they were transferred to Mars all analogy would be lost at once, because they would become totally *invisible.* None of the moon's features bears any notable similarity to the canals of Mars.

USING THE AMERICAN EPHEMERIS.

FREDERIC CAMPBELL,* Sc. D.

Send one dollar to the Superintendent of Documents, Government Printing Office, Washington, D. C., and you will obtain a copy of "The American Ephemeris and Nautical Almanac," for the current year, or for either of the two following years that you name. The value for 1915 has 742 pages, made up of such masses of figures as may well appall the average amateur astronomer. The book is invaluable for professional astronomers and for navigators. But no effort has been made to make it popular, and to wish your dollar back will be very natural after a cursory examination.

While far more than 99% of the matter contained will be of no service whatever to the amateur, yet, in the remaining less than 1%, there is very valuable and interesting information, which can be dug out without much labor. If one take a diary or date book, and fill it in from this source, he will soon discover that he is constructing his own almanac, to which he can make constant reference as the days and months go by.

To the following items he will want to give attention:

1. The phases of the moon, day, hour and minute, Greenwich time, which he must translate into local time, an interesting process.

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2. The moon's perigee (nearest) and apogee (farthest), also in Greenwich time.

3. The moon's librations, east and west. These he will have to obtain from some other source, like Jayne's Almanac, to be had at the drug stores for the asking.

4. The moon's farthest north and south. These may be determined from the tables giving the moon's declination hour by hour, or from the moon's longitude and latitude table.

5. The moon's nodes, ascending and descending; this to be obtained from auxiliary almanac as above.

6. The moon's age; to be counted, day by day, from the day of new moon.

7. The discs of Mercury, Venus and Mars; found in the tables showing extent of illumination of the discs in percentages.

8. The light-time of Mars and Jupiter, from tables showing how long their light takes to travel to earth at different times.

9. Aspects of Jupiter's four principal satellites, graphically presented, their groupings, missing satellites, etc.

10. The stellar magnitude of various planets at different times, enabling one to compare their changing brilliancy with that of leading first-magnitude stars.

11. Occultations of planets and of principal stars that may be selected from the large number occulted, determined by the magnitudes given.

12. Eclipses. Not only are the facts given, but maps presented, showing the regions affected in case of solar eclipses. The total eclipse of the sun, visible in America in 1916, is soon to be reckoned with.

13. Times of rising and setting of sun and moon, to be obtained from auxiliary almanac. Day's length determined in connection therewith.

14. Various passing phenomena, known as "planetary configurations," conveniently covering two consecutive pages, and showing: a. conjunctions of planets with each other; b. conjunctions of planets and moon; c. planets' greatest brilliancy; d. conjunction of planets with sun; e. planets at quadrature; f. planets at opposition; g. planets' perihelion and aphelion; h. earth's perihelion and aphelion; i. planets' nodes; j. Mercury's and Venus' greatest elongations; k. planets stationary; l. solstices and equinoxes; m. Mercury's and Venus' greatest heliacal latitude north and south.

The process of making one's own almanac in this manner the writer finds to be of great interest; unconsciously one is familiarizing himself with many things about the heavens; and his self-made almanac, growing day by day, will mean more to him than any other.

Beaver Falls, N. Y.

THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

[*Continued from page 31.*]

GALILEO GALILEI.

Galileo* mentions the time of his first observations of the solar spots in four distinct places, as follows:

1st. In a letter to Giuliano de' Medici, the Ambassador of the Grand Duke of Tuscany at Prague.

2nd. In the first of his three letters to Welser.

3rd. In the *Dialogues on the Two Chief Systems of the World.*†

4th. In a letter to Cardinal Maffeo Barberini.

To Giuliano de' Medici he writes:‡

The celestial discoveries are not yet at an end, it is about 23 months¶ and more since I began to see some dark spots on the sun. And also in the past year‖ in the month of April, being in Rome, I showed them to divers prelates and other gentlemen. Since then the report having been spread abroad they have been observed

* Born February 15, 1564, died January 8, 1642. For a most interesting and inspiring account of the life of Galileo, the reader should consult, *Galileo, his Life and Work*, J. J. Fahie. New York, 1903.

† *Dialogo de Galileo Galilei Lincei .. sopra i due Massimi Sistemi del Mondo Tolemaico, e Copernicano.* Firenze 1632.

‡ *Galileo Galilei Opere, Edizione Nazionale,* **11**, 334. All references to Galileo's writings and correspondence are to the National Edition. For brevity this will be indicated by " *Gal. Op.*"

¶ In the *Edizione Nazionale* this figure is given as 15, with the footnote, "The figure is a little uncertain". The uncertainty of this figure has been the occasion of considerable discussion, caused largely because the figure was incorrectly given in several of the earlier editions of Galileo's works. Plana was the first to call attention to these errors in his *Réflexions* (*Op. Cit.* 168), where the handwriting of Galileo is reproduced in fac-simile, showing the manner in which the words "circa 23 mesi" are written. After examining this fac-simile, one appreciates that the 23 might have been mistaken for 13, but it is hardly conceivable that it could have been mistaken for 15. The figure 3 is unquestionable, but the 2 might be mistaken for 1. All the authorities, however, who have considered the matter agree in believing that 23 is the correct reading of this number. But Favaro in speaking of this letter remarks (*Op. Cit.* 737)."..... in the autograph at the library of the Imperial Observatory at Vienna we read clearly enough that this fact (the discovery) dates back '23 months and more' as Galileo writes." Just why in the face of this the figure should be given as 15 in the *Edizione Nazionale*, of which Favaro is the Editor, is not easy to answer.

‖ This fact makes the 2 in the figure 23 mentioned above, unquestionable.

in many places, and various opinions have been written and spoken about this matter, but all far from the truth. I have finally convinced myself of this, which would at first sight perhaps seem very strange to you, namely, that these spots are not only near the sun, but contiguous to its surface, where continually some are being produced and others dissolved, some being of short and others of long duration; that is, some disappear in 2, 3, or 4 days, others remain for 15, 20, 30, and even more. They continually change shape, and these shapes are very irregular. They condense and they dissolve, some of them being at times very black, and others not so dark. Often one divides into 3 or 4, and at other times 2, 3, or more, coalesce into one. They have moreover a regular movement, by which they are all uniformly carried around by the solar globe itself, which revolves in a lunar month, with a motion similar to that of the celestial sphere, that is from the west to the east. These spots never occur near the poles of the sun's rotation, but only about the equator, nor are they found further from it than about 28 or 29 degrees, as far toward one pole as another; which region corresponds with the torrid zone of the earth, or to speak more correctly to that region which includes the greatest declinations of the planets.

The date of this letter, which is in autograph, is the 23rd of June 1612 which would make the discovery date back to July 1610.

In the first of the three letters to Mark Welser, already referred to, Galileo writes:*

And in the first place there is no doubt whatever that these are real things, and not simple illusions of the eye or of the glasses, ... and I have been observing them for the last eighteen months, and I have shown them to several intimate friends of mine, and last year at just this time in Rome I showed them to many prelates and other gentlemen.

As the date of this letter is May 4, 1612, the statement that he had been observing the spots for eighteen months previously, would place the time of discovery early in November 1610. This apparent contradiction in dates has led to considerable discussion. In explaining it Plana† and Favaro‡ are agreed in believing that the first date refers to the time of actual discovery in July 1610; the second date, November, referring to the time when the observations were resumed after Galileo's removal from Padua to Tuscany in September 1610; he being able once more to resume the investigations and studies which had been interrupted by the inconveniences of moving. This argument is based on the words of Galileo himself. In the letter to Giuliano de' Medici, he writes:

It is nearly 23 months and more since *I began to see* some dark spots on the sun. (Ma sono circa 23 mesi e piu che *cominciai a vedere* nel sole alcune macchie oscure).

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* *Gal. Op.* **5**, 95.
† *Op. Cit.* 168.
‡ *Op. Cit.* 738.

While to Welser, he writes:

And I have been *observing* them for the last 18 months. (Ed io le *ho osservate* da 18 mesi in qua).*

The writer agrees with the explanation of this apparent contradiction as given by Plana and Favaro, namely, that the two dates refer to two different occasions; the first one to the approximate time of the discovery or first observation of the spots, the second referring to the observations which were resumed after Galileo's arrival in Tuscany. Why Galileo did not mention the earlier date in the letter to Welser, we have apparently no means of determining.

In the *Dialogues on the Two Chief Systems of the World*, published in Florence in 1632, alluding to himself, Galileo puts the following words in the mouth of Salviati:†

He was the first discoverer and observer of the solar spots, as well as all other celestial novelties, [was] our member of the Accademia dei Lincei; and these he discovered in the year 1610, while he was still lecturer on mathematics at the University of Padua, and there and in Venice he spoke of them with various people, some of whom still live; and a year later in Rome he showed them to many gentlemen, as he asserts in the first of his letters to Mark Welser the Magistrate of Augsburg. He was the first, who, contrary to the opinions of those too timid and too jealous of the unalterability of the heavens, affirmed that these spots were material bodies, which were produced and dissolved in a short time, which were located contiguous to the body of the sun, around which they revolved, or were carried by the solar globe itself, which rotates in its place, without changing its position, in about a month.

In the letter to Maffeo Barberini, Galileo writes:‡

About 18 months ago, looking with my telescope at the body of the sun when it was near to its setting, I perceived on it some rather darkish spots; and returning several times to the same observation I perceived that they were changing their positions, and that they were not always the same in form nor in arrangement; and sometimes there were many of them, sometimes few, and sometimes none at all. I showed this strange thing to my friends, and just last year in Rome I showed it to many prelates and men of letters.

* Carrara (*Op. Cit.* 217) does not support the above explanation, not believing that much reliance should be placed on such indefinite statements, nor that the date in the letter to Giuliano de' Medici refers to the time of actual discovery, since neither the day nor the hour when the discovery was made are mentioned. Regarding the statement in the letter to Welser, Carrara believes that this refers to the times when the spots were shown to friends, that is, a simple view of the spots and not the beginning of a series of continued observations. The objection is also raised that Galileo should have made the more accurate statement in the reply to the letters of Apelles which was addressed to Welser, rather than in a letter to Giuliano de' Medici. Carrara also points out the great advantage that it would have been to Galileo in the unfortunate quarrel which followed, if in his earlier letters he had made more accurate statements regarding the time of discovery. However, reasoning of this kind, namely, what Galileo ought to have written is somewhat beside the question. The important point is to find the best interpretation of what Galileo did write, and not what he should have written.

† *Gal. Op.* **7**, 372.

‡ *Gal. Op.* **11**, 304.

This letter is dated June 2, 1612, and according to this, dating back eighteen months, the time of discovery was early in December 1610. This is at variance with the other statements, and since the only part of the letter which is in autograph is the signature, too great reliance should not be placed on it. From the similarity of the wording of many of the statements made in it with those in other letters, and the fact that only the signature is in autograph, one is led to believe that the letter may have been written for Galileo, at his request, by a friend or pupil. Accompanying the letter is a series of nine drawings of the sun, showing the spots day by day from May 3-11, 1612.

That Galileo had observed the spots while at Padua, and that he had shown them to his friends is incontestably affirmed by the declaration of Father Fulgenzio Micanzio, in a letter written after the publication of Scheiner's *Rosa Ursina**, in which that author claimed the priority of the discovery of the solar spots. The letter is dated September 27, 1631. Micanzio writes:†

> I remember most distinctly that when you had made here the first telescope, one of the things that you observed were the spots on the sun. And I could name the place and the point, where on a white card you showed them with your telescope to the Father of glorious memory [Paolo Sarpi]. And I remember the discussion that there was, first whether it was an illusion of the glass, or vapors intervening; and then after repeating the experiment, it was concluded that it was a fact and worthy of being philosophised upon; and then you went away. The memory of it is as fresh to me as if it were yesterday.

This letter is the strongest, and apparently the only direct testimony for the observations of the spots at Padua from one who was actually present at the time. It is to be noted that the statements of Galileo in the letter to Giuliano de' Medici and in the *Dialogues* are confirmed by the letter of Micanzio's and by Viviani in his *History*, which will be quoted later. It is true that this letter was written twenty years after the event had taken place, but the wording is so clear and the statement so convincing, the details so carefully given, that unless we have some real reason for doubting the veracity of the author, the letter almost compels confidence in the author's statement that, "The memory of it is as fresh to me as if it were yesterday." We know that Galileo left Padua early in September 1610 to accept the chair of Mathematics at the University of Pisa.‡ Hence, there are the very best of reasons for asserting that Galileo's first observations of the spots were made sometime before this date, that is, during the summer months of the year 1610.

* *Rosa Ursina* is the title of Scheiner's great book on the solar spots, published in 1630.

† *Gal. Op.* **14**, 298.

‡ Fahie, *Galileo, his Life and Work*, p. 121.

The announcement of Galileo's discoveries of the mountains of the moon, and the satellites of Jupiter was made in the tract entitled *Siderius Nuncius*, published at Venice in March 1610; later in the same year were made the anagrammatical announcements of the triple bodied Saturn and the phases of Venus. The news of these discoveries spread over all Italy, creating intense excitement among the people, and consternation among the learned and the Church authorities. Galileo had already become known for his radical and revolutionary views upholding the Copernican theory of the solar system, and altho the statements in the *Siderius Nuncius* did not support this in so many words, the inference could easily be seen by his readers, and the result was a tremendous explosion of incredulity and malice. It is not necessary to go into the details of all this, but it was in consideration of the extraordinary interest, friendly and otherwise, excited by these epoch making discoveries, and the possibility of their being used against him by his enemies in Rome, who already were numerous, that Galileo thought it advisable to go there himself and to acquaint at first hand the dignitaries of the church and the savants with his work in the heavens. These people, he argued, must first be made to see the facts with their own eyes, so that they may be able to comprehend and assent to the conclusions to be drawn from them.

Galileo had removed from Padua to Pisa and was now under the authority of Cosimo II, Grand duke of Tuscany. Therefore on the 15th of January 1611, he wrote to Belisario Vinta, the secretary to the Grand Duke, informing him of his designs, adducing the above reasons and requesting the necessary leave of absence. The permission not only was granted, but the Grand Duke undertook to defray all expenses. Illness, however, intervened, so that it was not until toward the end of March that Galileo was able to set out. He was received with the greatest distinction by princes and all the church dignitaries, and was lodged at the Tuscan Embassy, with the Ambassador.

There are numerous letters and other documents which testify to the public exhibition of the spots and the other "celestial novelties." Piero Dini writes to Galileo from Rome on May 2, 1615:*

> I find myself here in the Monte Cavallo Gardens of the most illustrious Bandini, where you showed me for the first time the solar spots.

Angelo de Filiis, going into greater detail, writes:†

> [Galileo] does not depart from Rome before he not only indicates to you with words that the sun has spots, but shows it to you in fact; and he shows the spots from more than one place, as in particular the Quirinal Gardens of the most

* *Gal. Op.* **12**, 175.

† *Gal. Op.* **5**, 81.

illustrious Cardinal Bandini, there being present at the time the Cardinal with the Most Reverend Monsignori Corsini, Dini, Abbate Cavalcanti, Signor Giulio Strozzi and other gentlemen.

Vincenzio Viviani, the first biographer and the last and best beloved pupil of Galileo, in his "Narrative History of the life of Galileo," (*Racconto Istorico della Vita de Galileo*) writes regarding this:*

About the end of the month of March 1611, Galileo being desired and expected by all Rome, went there, and in the following April showed the new sights in the sky to many Cardinals and Prelates, and especially in the Quirinal Gardens,.....he showed the solar spots. And this was six months before the earliest observations made by a certain unknown Apelles, who then pretended the priority of this discovery in vain, for his first observations were not made before the month of October following.

Gio. Battista Agucchi writes to Galileo from Rome on June 16, 1612:†

It is now more than a year since you spoke to me of the solar spots and concerning their movement about the body of the sun.

To adduce other evidence in support of the public exhibition of the spots at Rome would be superfluous. However, it is important to establish the time of Galileo's sojourn in that city. Fortunately the dates of his arrival and departure can be fixed with great exactness. Giovani Niccolini writes to Cosimo II, the Grand Duke, from Rome on March 30, 1611:‡

Mess. Galileo Galileo arrived here yesterday, to whom, in conformity to the command in your letter of the 27th [of February], has been given lodging together with two of his servants.

Piero Guicciardini, who succeeded Niccolini in the office of Resident for the Grand Duke, writes from Rome on June 4, 1611, to Belisario Vinta:¶

This morning Galileo departed from here, whom I have lodged in my house and tried to honor and care for as a person who is dependent upon and pleasing to the Most Serene Patron.

Hence, Galileo was in Rome from March 29, to June 4, 1611, and during this interval he showed the spots to the "many Cardinals and reverend gentlemen."

While Galileo was exhibiting the spots and other celestial objects in the Quirinal Gardens, a letter dated April 19, 1611,‖ was sent by Cardinal Roberto Bellarmine to the Most Reverend Father of the Collegio Romano inquiring concerning the truth of these new celestial discoveries made with the telescope. In consequence, four members of

* *Gal. Op.* **19**, 612.
† *Gal. Op.* **11**, 329.
‡ *Gal. Op.* **11**, 78.
¶ *Gal. Op.* **11**, 121.
‖ *Gal. Op.* **11**, 87.

the Collegio Romano were appointed, and instructed to examine this matter and to report. The members of this commision were the Fathers Cristoforo Clavio, Cristoforo Grienberger, Odo von Maelcote, and Gio. Paolo Lembo; all being members of the order of Jesuits. The commissioners were of course constrained to admit what had been long denied and ridiculed. Their report was submitted with the date of April 24, 1611.* Altho the spots are not specifically mentioned in the report, they must have been shown to at least one of the members of this commission; for Maelcote writes to Kepler from Brussels, 11th of December 1612:†

> Have those solar spots taught nothing new to your domination concerning the motion of the sun about its center? These spots, altho Galileo showed them to me in Rome and others in Germany, (fearing with you that the lens might burn the eye) I neglected to observe them, until having read of your device and somewhat modified it, I learned to observe by passing the rays of the sun through a dioptric tube provided with both its concave and convex glass and properly extended, on a tablet or card placed opposite to the sun. I wonder indeed that these spots do not recur in the same position and order if they move with an epicyclic motion, since they seem to hasten in front of the sun towards the west with the same velocity.

The reality and actual existence of the spots was thus admitted by the enemies of Galileo. Certain of them now attempted to rob him of the credit for the discovery. The foremost of these was Scheiner, who was of course aided in this by his co-religioners, the Jesuits. One of the strongest arguments of these enemies of Galileo in opposing his claims for the discovery, was that he did not announce it in an anagrammatical form or otherwise as he had thought well to do for the phases of Venus and the triple Saturn. "Meanwhile to speak of the spots is not to write of them; to see the spots is not to publish your writings," proclaims Scheiner.‡ Why Galileo did not endeavor to assure for himself, by his usual methods, the credit for the priority of discovery when he first saw the spots is not difficult to guess. One can suppose that in consequence of the discoveries of the satellites of Jupiter, the triple-bodied Saturn, the phases of Venus, and the mountains of the moon, with the unparalleled controversy that had been let loose by the conclusions that he had drawn from them, Galileo might well pause before announcing the discovery of such unstable objects as the sun-spots; which, changing their form and position, vanished and reappeared before his very eyes. However, Galileo himself tells us in his first letter to Welser his reasons for not announcing the discovery.¶

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* *Gal. Op.* **11**, 92.
† *Gal. Op.* **11**, 445.
‡ *Rosa Ursina*, lib. I. p. 25.
¶ *Gal. Op.* **5**, 94.

I have kept silence in the hope of being able to give some satisfactory answer to your questions regarding the solar spots, concerning which you sent me the brief discourses by the unknown Apelles. But the difficulty of the matter, and my not having been able to make many continued observations, have kept me and still keep me undecided and irresolute, for it is more necessary for me than for many others to proceed with caution and circumspection in announcing any novelties. For the things recently observed, which are far from common and popular opinion, and which as you well know have been vigorously denied and opposed, place me in the necessity of being obliged to conceal and keep silent regarding any desirable new explanation, unless I have some demonstration of it which is more than convincing and plausible. Because by the enemies of novelties, the number of whom is infinite, every error no matter how slight would be considered a most grevious fault, for the custom has been established that it is better to agree in an error with everybody, than to be alone in reasoning correctly.

In this connection, Viviani in his *History of the Life of Galileo* writes as follows:*

Continuing the celestial observations with the telescope, in the beginning of July he discovered Saturn to be tricorporate, ... He also saw in the face of the sun one of the spots, but at that time he did not announce this other novelty, which might so much the more draw upon him the envy and persecution of many obstinate Peripatetics (mentioning it only to some of his most intimate friends of Padua, Venice and elsewhere), in order that he might first assure himself with repeated observations, and thus be able to form a theory of their nature, and to pronounce his opinion of them with at least some probability.

The truth of this, namely, that Galileo was for some time in doubt regarding the true explanation of the spots and was still uncertain whether the spots were a part of the sun itself, or were of the nature of small planets revolving around it, is indicated by the first printed work by Galileo in which the spots are mentioned. This is the "*Discourse on Floating Bodies,*" (*Discorso intorno alle cose che stanno in su l' acqua o che in quella si muovono*). Galileo had finished writing this by the end of October 1611; it was licensed by the Holy Office on March 5, 1612, and appeared from the printer's hands during the latter part of May, In it, Galileo refers to the spots in the following words:†

I add to these things the observations of some dark spots which are perceived in the body of the sun, which changing their positions in it offer an opportunity for argument whether the sun revolves in its place, or whether these spots are other celestial bodies like Venus and Mercury, and are revolving around it, invisible at other times on account of their small digressions from the sun, which are less than those of Venus and Mercury, and hence are only visible when they interpose between the sun and our eyes. The proof of these things ought not to be neglected or overlooked.

* *Gal. Op.* **19**, 611.
† *Gal. Op.* **4**, 64.

Galileo had evidently more nearly convinced himself of the true nature of the spots by the time that he wrote the first letter to Welser. For in a letter to Prince Frederico Cesi, the founder of the Accademia dei Lincei, dated the 12th of May 1612, or about a week after the first letter to Welser, he writes:*

> About these spots, I finally conclude and believe that I can firmly prove it; they are near to the surface of the solar globe, where they are being continually created and dissolved, as are the clouds around the earth, and by the same sun they are carried around as it revolves in its place in a lunar month with a revolution similar to that of the other planets,.....

And with greater assurance he writes to Cesi again, two weeks later.†

> I am very resolute and certain, that the fact will be found as I say; that is, that the spots are in the surface of the solar body itself, which carries them around, revolving in its place in the space of about a lunar month, from west to east in conformity with all other celestial motions. Here they are produced continually and they are dissolved, ... imitating in short the particular behaviour of our clouds, which being obedient to the greatest and universal movements of the earth, daily and annually do not fail to change their shapes and places among themselves, but within very narrow limits. Do not have any doubts regarding this, for I have the necessary demonstration of it.

In the second edition of the *Discorso* which appeared in August 1612, Galileo expresses himself more resolutely:‡

> Continued observations have finally convinced me that such spots are matter contiguous to the surface of the solar globe, ...and by the rotation of the sun, which in about a month finishes its period, they are carried about its circumference; an event which is of greatest import in itself, and greater in its consequences.

It is thus seen that for a considerable time after the first observations; that is, until May 1612, Galileo was still uncertain regarding the true nature of the "dark spots which are perceived in the body of the sun," and hence hesitated to make the formal announcement. It is likely that the announcement would have followed in due time, when, after having convinced himself of what the spots were, he would be prepared to withstand the onslaughts of the Peripatetics. But before this the public demonstration at Rome had been practically forced on him. It is not unreasonable to suppose that Galileo believed that this demonstration was a sufficient announcement of the discovery and that no other was necessary.

The news of the sun-spots spread abroad in Italy, and, as we shall see later, in Germany. In Italy there were many who procured telescopes, and following Galileo's example, made numerous observations of the "celestial novelties." Among these, two are worth mentioning; the

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* *Gal. Op.* **11**, 296.
† *Gal. Op.* **11**, 301.
‡ *Gal. Op. A*, 64.

Cavalier Domenico Cresti di Passignano and Ludovico Cardi da Cigoli, two painters, both lifelong friends of Galileo. Passignano was the first to see the spots, but his friend Cigoli wrote to Galileo describing the observations. Cigoli writes from Rome on the 16th of September 1611, as follows:*

I wanted to write to you with the last post that Passignano has obtained a telescope similar to the one that you have, from a friend in Venice. He says that with it he has observed the sun many times, in the morning, noon, and evening..... and that he has observed in the sun as many as eight spots, sometimes more, sometimes less, and in various aspects, sometimes darker and sometimes more faint (spenti), almost as if they had burned (infusi) themselves more or less into the center and middle of the luminous body,.....And he says he is sure that they move around within the said sphere of the sun; but I told him that he should observe them for a week, and sketch them and inform you about it. He said that he had done so, and that he positively insisted that they moved, and for that reason they go wandering through the solar body. However, I tell you this for your information.

Accompanying the letter is a rough sketch showing the positions of the spots. Cigoli writes other letters to Galileo concerning Passignano's observations. Finally Passignano writes to Galileo on December 30, 1611, as follows:†

I believe that Sr. Ludivico [Cigoli] has written to you how with my telescope I have made some observations of clouds (nobi) on the sun, of which I am sending you a copy [this drawing is lost], where you will see the day and the hour that they were seen. I have shown them to Fathers Panberger and Malcotto [Grienberger and Maelcote], who say that they have seen them, and have asked me how it is possible to endure the sight of the sun? I have told them that in front of the small glass [eyepiece] I put a piece of blue glass which kills the heat of the sun. Now I would like you to see them, and if you will advise whether they agree with your observations and where they fail to agree, it will be pleasing to me.

Passignano was a careful observer, and, altho his theory of the spots would not stand present day tests, he is one of the first to give intelligent arguments for believing that the spots are a part of the sun itself. He writes to Galileo from Rome on the 17th of February 1612:‡

Having seen a discourse which came from Germany about the spots which are seen on the sun [presumably the Apelles' letters], and having spoken about it with Father Panberger, who holds the same opinion as the writer of it, namely, that the spots which he sees are stars like those around Jupiter, I am of the contrary opinion, because I have made observations for five months, and I have not been able to perceive that they are outside of the sun. But I say that they are inside the body of the sun, because in the said time it is impossible that I should not have seen some of them in the neighborhood of the sun, as would happen if they were outside of it. But I have never seen them near the edge, instead they are first seen a little distance from it, not being plainly visible, and gradually as they

* *Gal. Op.* **11**, 208.
† *Gal. Op.* **11**, 253.
‡ *Gal. Op.* **11**, 276.

approach the middle they are seen more plainly. And similarly I have seen some in one day appear in the middle all at once, and then in several more days finish their course and vanish. And also I have seen some which when they have come to the middle vanish in a few days, and are no longer seen; and on account of these proofs I cannot believe that they are detached from the sun. If they are suddenly seen near the middle and finish their course in a few days, it must mean that they come suddenly, change their course a little and go away gradually; and on the other hand I have seen some come slowly and when they have become fainter, vanish near the middle. From which it would follow that their motion would be swift and slow and hence irregular, which is a thing I do not believe possible, for I believe that all the celestial bodies have a regular motion which does not change. I believe them to be inside the body of the sun, not only on the surface, but that they go down to the center and come back to the surface.

The letter continues, questioning Galileo whether he had observed the same things and requesting an opinion on the subject.

Cigoli writes a long letter to Galileo from Rome, dated March 23, 1612, in which he describes his methods of observing and the spots as they appear to him. His theory, however, shows very evident signs of the influence of Passignano. He mentions his telescope, which he declares to be a good one, because with it he can see the hands on the clock on St. Peter's from his position on Santa Maria Maggiore. About the spots, he writes:*

The spots on the sun, I could not look at them with the little white glass, because tears came to my eyes, but then with a thick green glass and since it was concave like the white one, I placed on it another plane glass also green, I had no difficulty in observing them at any time. And from Santa Maria Maggiore I have made the 26 observations which are here enclosed, ... I would assert that in the sun there are things which are like bits of straw floating in a caraffe, which moving through it come to the circumference and are visible, then go down to the center, and as they go down become fainter. I do not know, but it seems to me most likely that they are stars which in passing interpose between us and the sun, altho I have some doubt of this (!). One reason is, that I have never seen them right at the circumference, but very close, and always entering from the east and going toward the west, but I have never seen any of them go to the very edge. I have seen many oval shaped (ovate), especially near the edge, but Father Grembergero [Grienberger] says that this is because we see a portion of the illuminated side, and hence they appear oval;† which reason would satisfy me, if it were not contrary to what my senses show me. But the oval ones that I have seen appear to me to be so, with the darker portion toward the center of the body of the sun, and the others appear round. Now I do not believe that they appear this way to me only, for I have shown it to others; nor do I believe that they are imperfections in the telescope, because I see them of various shapes, round and oblong; nor do I think that they are a group of stars, because in making a circuit they do not leave a space between themselves and the solar body. But the thing that confuses me is that the darker side is toward the center of the solar body; however, this not being "food for my teeth", I leave it for you to think about.

* *Gal. Op.* **11**, 286.

† Grienberger believed that the spots were planetary bodies, which when off the disk would show "phases" like the moon.

This appearance of the spots, with the darker side towards the center of the disk, was also noticed by Scheiner who, either possessing a better telescope or better eyesight, reasoned that it was caused by the depth or thickness of the spots. It was later observed by Wilson of Glasgow in 1774, who in consequence announced his famous "depression" theory of the spots.

The "26 observations" referred to by Cigoli, are a series of drawings accompanying the letter and showing the appearance of the spots. The series commences with the 18th of February, and continues to the 23rd of March. The drawings show no details, but the progressive movement of the spots and groups across the disk is readily apparent.

Closely allied with the questions concerning the nature of the spots, was that of the sun's rotation. As will subsequently be seen, Fabricius preceded Galileo in actual time in publishing his belief in this fact, but he stated his conclusions very guardedly. It appears that Galileo's first explicit mention of his belief in the sun's rotation is contained in a reply to the letters of Cigoli mentioned above. This reply is dated October 1st 1611; Galileo writes:*

> I am glad that Sr. Passignano continues observing the sun and its revolution, but it is necessary that you should tell him that the part of the sun which is lowest when rising is highest when setting, whence it might appear to him on account of this that the sun had some other revolution in its place beside that which I really believe that it has, and which I think can be observed by the changes of the spots.

To this might be added, that the suspicion "whether the sun revolves in its place" had been expressed in the first edition of the *Discorso* which was finished at about this time.

In the first letter to Welser, having given his reasons for not believing that the spots are wandering stars between the earth and the sun, visible only when transiting the disk, which views were held by Apelles, Galileo expresses his belief in the rotation of the sun and the solar nature of the spots as follows:†

> I do not believe that they are either fixed or wandering stars, nor do I believe that they move around the sun in separate circles at a distance from it; and if I were to state my opinion in confidence to a friend and patron, I should say that the solar spots are produced and dissolved at the surface of the sun, and that they are contiguous to it; and that this same sun revolving in its place in about a lunar month carries them with it, and perhaps bringing back some one of them which has endured longer than the time of the sun's rotation, but so changed in appearance and surroundings as to be scarcely recognizable.

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* *Gal. Op.* **11**, 214.

† *Gal Op.* **5**, 111.

The successive observations having confirmed Galileo in the opinions which were at first hesitatingly expressed, he reiterates his conclusions and the reasons for holding them at the beginning of the second letter to Welser. *

The dark spots, which are seen with the telescope on the disk of the sun, are not far distant from it but are contiguous to it, or are separated by such a small interval that it is imperceptible. Moreover they are not stars or other solid bodies of long duration, for continually some are being produced and others are being dissolved; some being of short duration as 1, 2, or 3 days, and others of longer duration as 10, 15 days, and I believe others of 30, or 40 days or more. They are mostly of irregular figure and they change shape continuously, some with rapid and large changes, others more slowly and with less variation; moreover they increase and decrease in density, some appearing to condense and at other times to become rarified and diffuse; and besides changing into various shapes, one may be seen to divide into 3 or 4, and often many are united into one, which happens more frequently near the circumference of the solar disk than near the middle. Besides these irregular and individual motions of uniting and separating, condensing and changing figure, they have a maximum, common and universal movement, with which uniformly and in parallel lines they move over the body of the sun; from the peculiarities of this movement it becomes known, first, that the sun is absolutely spherical, second, that the sun revolves on itself about its center bearing the spots with it in parallel circles and completing its revolution in about a lunar month, with a revolution similar to that of the orbs of the planets, namely, from west to east. Moreover, it is to be noted that the majority of the spots seem to occur always in the same region or zone of the solar body, comprised between two circles corresponding to those which include the declinations of the planets, and beyond these limits as yet not a single spot has been observed, but all between these confines; so that neither towards the north nor towards the south do they appear to depart from the great circle of the sun's rotation more than about 28° or 29°..... The fact that we see them all moving as a whole with a common and universal movement is a sure argument that this movement can have only one cause, and not that each one of them is going around the body of the sun like a small planet at different distances and in different circles. Hence, we must necessarily conclude, either that they are all in a single sphere and like the stars are carried around the sun, or that they are in the body of the sun itself which revolves in its place and carries them with it. Of which two suppositions, the second appears to me to be true, the other false.

And later in the same letter, after giving numerous arguments and proofs, he continues:†

From the things thus far mentioned, it seems to me, if I am not mistaken, that the necessary conclusion is that the solar spots are contiguous or very near to the body of the sun; they are objects which are not permanent or fixed, but variable in figure and darkness.....and their motion around the sun is manifest and indubitable. But to determine whether this results because the body of the sun itself rotates and turns in its place carrying the spots with it, or because the solar body remains fixed while the surrounding medium is in motion taking the spots with

* *Gal. Op.* 5, 116.
† *Gal. Op.* 5, 133.

it, remains in a certain way doubtful, being perhaps the former or the latter. However, it seems to me more probable that the movement is of the solar globe rather than the surrounding medium. And I am led to believe this, first, because of the certainty that I have that the surrounding medium is fluid, thin and yielding; from the fact that the solar spots contained in it are seen so easily to change their shape, to coalesce and separate, which things could not take place in a solid and consistent medium (a proposition which will seem quite new to the common philosophy). Now a consistent and regular movement, such as is common to all the spots would not seem to have its cause and origin in a fluid substance composed of parts which are not coherent, and are hence subject to commotion and disturbance by many accidental movements, but rather in a solid and consistent body where there is of necessity a single motion of the whole and of its parts, and it is believed that such is the solar body in comparison with its surroundings. Such a movement would then be imparted to the surrounding medium by contact, and to the spots by the medium, or imparted directly to the spots by contact and would carry them about.

In the third letter to Welser, written on December 1, 1612, Galileo supports his former conclusions regarding the movement of the sun with the additional evidence obtained from the motion of the faculae, which are here described for the first time:†

I hope that Apelles will be satisfied with what I have said to date, especially when he reads what I wrote in the second letter, and I believe that he will have no objection to make, not only to the great nearness of the spots to the solar globe, but also to its revolution about itself; in confirmation of which I add to the arguments that I gave in the second letter to you. In the face of the sun itself there are sometimes seen certain small regions which are brighter than the rest, which when diligently observed show the same movements as the spots; and I believe that no one can doubt the fact that these are in the sun itself, it not being creditable that outside of the sun there should be found any substance more luminous than itself; and if this be so, it does not seem to me that there should be any more reason for doubting the revolution of the solar globe. And such is the connection of the truths, that it follows in a similar manner that the spots are contiguous to the surface of the sun and are carried around by its revolution; no plausible reason appearing why these (if they were separated from the sun by much space) should follow its revolution.

Possibly Galileo was influenced by the letters of Passignano and Cigoli while pondering on the problem of the solar spots, but how much this influence amounted to we do not know. At any rate the force of Passignano's argument of the varying speed of the spots as they traversed the disk must have appealed to Galileo and helped to strengthen his opinion that the spots were a part of the sun itself, or at least must be very near its surface. He makes use of this argument many times in the letters to Welser, where he mentions the varying speed of the spots, the changes in their apparent distance from each other, the changes in the apparent dimensions and appearance of the spots near the center and the edge as they transit the disk; explaining

† *Gal. Op.* **5**, 219.

each with great detail and clearness, and concluding with the statement that these are phenomena which "could not be met with in any other but the circular motion made by divers points variously placed upon a globe which revolves upon its own axis."

These extracts from the writings of Galileo have been quoted, notwithstanding their length, because it is believed that they are essential in order to demonstrate how the idea of the sun's rotation arose and developed in his mind; and passing through many uncertain stages, gradually crystallized into a definite form. The statements which have been quoted, and the many more scattered through the letters to Welser, show clearly, however, that whatever hints Galileo may have received from the letters of such as Cigoli and Passignano, he far surpassed them, and utilizing to its fullest advantage every phenomenon of the motions, changes, etc., of the spots, formulated a theory of their motion regarding which there could be no further discussion.

It is quite certain that at the first Galileo believed that the axis of the sun's rotation was perpendicular to the plane of the ecliptic. This is mentioned in the third letter to Welser;* however, he afterward changed this opinion. But this will be discussed in more detail later.

The subsequent history of Galileo's observations of the solar spots is so involved with the history of Scheiner's investigations and with the quarrel between them for priority of discovery, that the subject will be discussed with Scheiner's observations in a later portion of this paper.

(*To be continued.*)

* *Gal. Op.* 5, 189.

THE TABLE OF ZEUS.

By Ptolemy the Astronomer.

"I am mortal—the thing of a day; I
know it. And yet when I trace
The stars in their spirals and rings,
as they turn and return overhead,

My feet are no more upon earth; I sit
down in the heavenly place;
I partake at the table of Zeus of the
food of the gods; and am fed."

[Translated from the Greek by an Oxford Scholar.]

REPORT ON MARS, No. 14.

WILLIAM H. PICKERING.

The Two Varieties of Canals.

As a result of the observations made at the last opposition, that of 1913-4, it is concluded that the dark areas on Mars, whether broad areas like the maria, or narrow ones like the canals, are of two distinct classes, those that are comparatively permanent, and those that are ephemeral. Soon after the northern polar snows began to melt, the cap was surrounded by a broad grey or brownish band, that, unlike the southern maria, never appeared green. It soon narrowed in places to a mere canal, bounding the cap on the south. This canal retreated towards the north with the snow, and as compared with many of the more southern features of the planet was distinctly ephemeral. The polar bays, of which there were four that year, all exhibited a similar shifting, but their deep blue color, at times, indicated water. All these shifting dark areas are believed to owe their darkness either to ground moistened by thawing, or to actual swamp. The darkness of the more permanent canals and green maria are thought to be due to vegetation.

To illustrate the difference between those two kinds of canals Table I has been prepared. The left hand side of the Table represents the best drawing made each day during the presentation of the planet preceding opposition, the other side the drawings of the presentation following, the two sides being arranged exactly alike. The first two columns give the date and longitude of the central meridian, the next the number of canals shown on each side of the meridian, the *P* indicating the preceding or eastern side. The last column indicates by a cross on which side of the meridian the polar band was most marked, as indicated either by its breadth or density, or both. When there is no choice between the two sides, the result is entered under the column headed *E*. The four polar marshes are not included in this estimate, each balancing off an equal length of canal, on the other side. Prior to opposition the limb is on the *F* side, after opposition on that of *P*. The subscripts $_l$ and $_t$ stand for limb and terminator.

With regard to the permanent canals, we find that in general both before and after opposition, six-tenths of them are found on the side of

TABLE I.

PERMANENT AND EPHEMERAL CANALS.

Before Date	ω	Permanent P_1	Permanent F_1	Ephemeral P_1	Ephemeral E	Ephemeral F_1	After Date	ω	Permanent P_1	Permanent F_1	Ephemeral P_1	Ephemeral E	Ephemeral F_1
Dec. 3	346°	0	1		+		Jan. 6	351°	1	0	+		
8	306	0	0	+			10	342	3	0	+		
10	273	4	1	+			12	338	2	2		+	
12	252	4	2	+			15	281	3	0	+		
13	237	3	3	+			17	284	5	0	+		
15	227	3	5		+		18	240	6	4	+		
16	192	2	4			+	20	222	7	5		+	
17	185	2	7		+		21	184	1	1		+	
18	177	0	6		+		27	163	0	1	+		
19	162	1	3		+		Feb. 1	158	1	4	+		
22	168	2	2	+			5	104	4	3		+	
23	172	2	5		+		7	75	3	1		+	
25	125	6	0		+		8	42	1	1	+		
29	155	1	2	+			10	50	0	2		+	
30	101	6	2		+								
31	64	5	5		+								
Jan. 4	5	1	2		+								
5	41	0	3		+								
Total		43	53	6	11	1			37	24	8	6	0
Per cent		45	55	33	61	6			61	39	57	43	0

the planet towards the limb. This side has slightly the greater area, and it is also rather better lighted. On the whole the preceding, that is the afternoon, side of the disk shows a slight excess of canals over the morning side, 80 to 77, but not more than might well be due to accident, on account of the small number of observations considered. For the ephemeral canals on the other hand, those that we have attributed to marshy conditions, we find that before opposition on 33 per cent of the dates they were most marked in the afternoon or preceding side, to only 6 per cent in the morning. After opposition, as the sun rose higher upon them, with the advance of the season, 57 per cent of the dates were most marked in the afternoon, and none at all in the morning. It therefore appears that the permanent canals are most marked on the limb side, and the ephemeral canals on the side when it is afternoon, regardless of limb or terminator. Indeed by watching the polar band, and estimating its breadth in a given longitude with regard to the breadth of the polar cap, we should actually be able to see the ground on Mars thaw out under the influence of our sun as the Martian day progresses. This has in fact been done here this past month on several occasions, a difference being noticeable in the course of two or three hours. This, and watching the fog clear and shift on the sunrise limb, brings before us rather vividly the meteorological conditions existing on our sister world.

But it is not only at the boundary of the snow that the ephemeral canals and swamps exist. Sometimes these canals lead away from the snow with a slightly southerly inclination. Again while the canal usually retreats with the snow, yet sometimes it is left behind and a fresh canal develops between it and the snow cap. Thus on December 10, 1913, the boundary canal was narrow and was clearly identified as Heliconius. On the 12th the snow had retreated somewhat to the north, and the canal was very broad and light blue in color. On the 13th it had again narrowed, and shifted towards the further retreating snow. On December 15 the snow had still further retreated, and the canal was now very narrow and clearly coincided with Pyramus. A month later on January 17 Heliconius was very faintly indicated, with Pyramus clearly marked to the north of it.

The Syrtis marsh is another example of an ephemeral dark area. The lakes and canals seen in the Protei region, described in Report No. 3 and figured in No. 8, are clearly examples of ephemeral markings, very different from the usual run of canals and lakes. That a lake or swamp 1000 miles in length, as shown in Report No. 8, Figure 22, should exist where nothing of the sort was seen four days previously, as shown in Figure 23, appears to us as little short of astounding. Similarly that the Protei lakes 200 and 300 miles in diameter should disappear in the course of a few days seems to us well nigh incredible. Clearly they must all have been very shallow bodies of water or mere marshes, and the surface of Mars in these regions must be very flat. If consisting of marshy land the marshes are not necessarily all at the same level, and might even be intersected by small ranges of hills, invisible to us. Nevertheless, such changes are certainly extraordinary and never occur upon either the Earth or Moon, the only other planetary bodies with those surfaces we are familiar. If due to the presence of water however, such changes are exactly what we should expect to find on Mars. Indeed had we known that the surface was so level, we might almost have predicted them.

The explanation is comparatively simple, and depends merely on the atmospheric pressure. On the Earth the pressure is so great that the boiling point of water is raised far above the mean temperature of the planet. Consequently evaporation and precipitation both take place slowly. On the moon the pressure is so low that the boiling point would be reduced to the melting point, and consequently water as such disappears entirely from the surface. Imagine now a planet with an intermediate atmospheric pressure. Let us suppose the boiling point reduced to the mean temperature of the planet. Steam would therefore rapidly condense to water at night, and the water would boil away by day into steam. Judged by appearances it would seem that on Mars

the boiling point is slightly but not far above the daylight temperature. Otherwise we should expect the marshy areas to be continually enveloped in cloud. This is not the case, although heavy clouds are often seen rising from them (Reports Nos. 3 and 4).

If the daylight temperature of Mars were 68° *F* (20° *C*), in order that water should exist on its surface, the pressure of its atmosphere would have to be at least five-eighths of an inch (17 mm). It is generally supposed to lie between one and three inches. Writers sometimes commiserate with the Martians for not having more water on their planet, but it would seem that they may perhaps thank their lucky stars that there is not more of it, else they might all be in danger of drowning! While it now appears improbable to us that the canals are devices for transporting water across the surface of the planet, it is possible that some of them may serve the opposite purpose, that of retaining the water as long as possible, so that all may not be carried at once to the other pole, by means of the regular aerial planetary circulation.

Permanent Changes of Surface.

In Report No. 7 we showed by means of a series of drawings the gradual changes that had taken place in that region of the planet following the Syrtis during the past thirty-six years. What is in some ways a more striking and interesting change is exhibited by the drawings in Plate II. The first observer to represent the surface of Mars completely and accurately as we know it today was Sir J. N. Lockyer, in 1862. He employed an aperture of 6 inches. Other early observers show certain features, notably the Syrtis itself, which can be readily identified at the present time, but most of their drawings show little else that is now recognizable, and the drawings themselves are clearly of but little value.

There are two features shown by Lockyer however that at once strike the modern observer as peculiar. If we examine his drawing, Figure 3, and compare it with Schiaparelli's map in our first Report, we shall recognize without difficulty Sabaeus on the extreme left and Solis Lacus on the right. South of Solis we shall recognize Tithonius, and note where it is joined to Aurorae, but what is that singular marking which fills the place now held by Juventae Fons? For convenience we will call it *X* and shall refer to it by that name hereafter. Starting now from Sabaeus and proceeding towards the center of the disk we first reach Margaritifer, and soon after its twin feature, another unrecognizable marking, which we will call *Y*. It will be noticed that while Lockyer does not show the point of Aryn, he does show Sigaeus

PLATE II

FIG. 1.
Secchi
1858 June 5, 9^h40^m

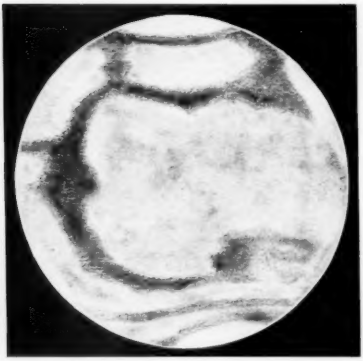


FIG. 2.
Secchi
1858 June 10, 9^h00^m

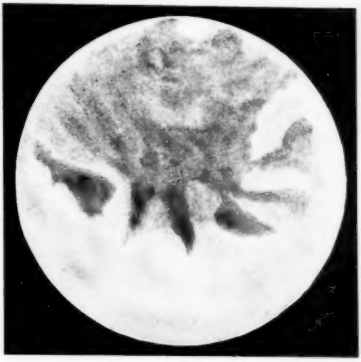


FIG. 3.
Lockyer
1862 Sept. 23, 12^h55^m

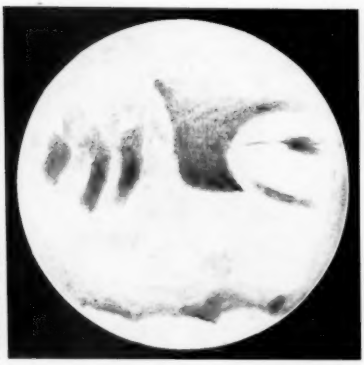


FIG. 4.
Kaiser
1864 Dec. 18, 10^h00^m

DRAWINGS OF MARS

Portus, the little bay where Phison and Euphrates join Sabaeus, also Daradax, the bay lying between it and the forked bay of Sabaeus. These are both very minute details, often not visible at the present day. They indicate the general accuracy of his drawing, and our surprise is the greater at the presence of the large unfamiliar markings *X* and *Y*.

Figure 4 is by Kaiser, drawn two years later. Aperture 7 inches. *X* does not appear on his drawing and the region looks much as it does at the present day (see Report No. 8, Figures 5 to 8) but *Y* is clearly shown, and equals Margaritifer in size. Sabaeus appears at the extreme left.

Figure 5 is by Dawes. Aperture 8 inches. He had a keen eye, and discovered the point of Aryn within the forked bay, which was formerly named after him. His sense of proportion was not good however, and he brings the bay much too near to Solis Lacus. He does not show *X*, but *Y* is even more prominent than in the previous drawings.

In Figure 6 Green, who was an artist by profession, and who necessarily had an excellent idea of proportion, represents this region very much as did Lockyer and Kaiser. He used a reflector of 13 inches aperture. Sabaeus is on the extreme left, and Solis on the right. He shows *X* quite as clearly as did Lockyer, although of a somewhat different shape, but of *Y* there is no sign whatever. That part of the drawing might have been made yesterday.

The drawing by Schiaparelli shown in Figure 7 aperture 18 inches, differs from our modern drawings only in the fact that the promontory to the right of Margaritifer extends much farther south than it does at present, or in Kaiser's or Green's drawings. There is no trace of either *X* or *Y*,—except as canals.

If we turn back to Secchi's drawing made in 1858, aperture 9.5 inches, Figure 2 is readily recognized with the Syrtis on the left, the forked bay of Sabaeus on the right and Sigaeus Portus, longitude 335° on the central meridian. Compare with Report No. 8, Figure 4. In Figure 1 computation shows that longitude 35° must therefore have been central much as in Figure 3, and it is clear that the three bays indicated must be Margaritifer, *Y* and *X*, the latter connecting, through Ganges with Acidalium, much as Aurorae did in 1913-4. Compare with Report No. 8, Figure 9. Secchi's representation of *X* is more like that of Green than it is like that of Lockyer, but it is clear that the same object was seen by all three.

We thus find *X* shown on three of these early drawings, and *Y* on four of them, in fact on all four of the earliest ones, drawn prior to 1865. Considering the general accuracy of these drawings even in minute details, we can hardly doubt that large dark areas on the planet have therefore really permanently disappeared in the past fifty

years. This it will be noted is quite a different matter from the extensive temporary changes that are now generally recognized as occurring upon the planet. In general the length of both *X* and *Y* may be taken at 500 miles. To adopt a terrestrial analogy it is much as if the group of the New England States had been converted into a permanent desert, or as if the same thing had happened to England and Scotland. These drawings are all taken from Flammarion I, 138, 139, 153, 177, 186, 278 and 475.

It is not easy to determine the exact date at which the *X* and *Y* markings disappeared from Mars. This is because the drawings made between 1864 and 1877 are of inferior quality to those that preceded and followed them, perhaps owing in part to the greater distance of the planet at opposition. According to Burton in 1871 the *Y* was still there. According to Green in 1873 its existence is doubtful, while Terby indicates plainly that it was not visible. In October 1877 Dreyer shows it on a drawing, while Green as we have already seen clearly indicates that in September it had disappeared. If we neglect Dreyer's drawing, it disappeared between 1871 and 1873. The evidence regarding the *X* is unsatisfactory. As we have seen, its location is now marked more or less by Juventae Fons. According to Schiaparelli the longitude of Juventae in 1877 was 61°, in 1888 it was 64°. In 1879 Lohse made it 68°. According to drawings by Professor Douglass, Mr. Slipher and the writer in 1914 (Report No. 8) its longitude was 52°, 68°, and 52°. We have here a total range of 16°, but since on Mr. Slipher's drawing Juventae is nearer the limb than on the others, we may accord his drawing half weight, and obtain a mean value of 55°. This compared with the mean of the three earlier values 64°, gives a range of 9° or over 300 miles! Clearly the longitude of this marking should be investigated.

The last drawing, Figure 8, is from an unpublished sketch made by Professor Douglass while at Arequipa in 1892. It is of interest as showing how the promontory to the right of Margaritifer, which Schiaparelli showed extending so far to the south, changed back to its present abbreviated form. It was not by a gradual shortening, as we might have naturally expected, but instead, a dark band stretched straight across it from east to west, cutting off the tip. This band was very dark and conspicuous, and is shown on a number of Professor Douglass' drawings, as well as on several others made at the same time by the writer. The region to the south of it later darkened. As far as known this band has never since been seen in the dark and distinct form that it had during that opposition.

Another striking fact which these earlier drawings impress upon us is the general tendency on Mars to duplication, and also to the produc-

PLATE III

FIG. 5.
Dawes
1864 Nov. 14, 12^h00^m

FIG. 6.
Green
1877 Sept. 1, 13^h10^m

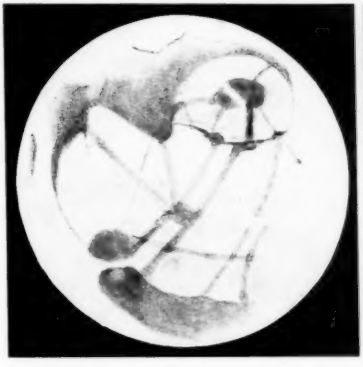


FIG. 7.
Schiaparelli
1890 June 9.

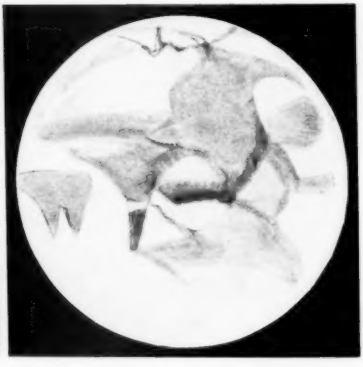


FIG. 8.
Douglass
1892 Aug. 15, 10^h40^m

DRAWINGS OF MARS

tion of triangular bays. The latest instance of this occurred at the last opposition, when Propontis and Castorius suddenly appeared side by side and just alike (Report No. 4, Figure 1). The forked bay of Sabaeus is another instance, and now we have Margaritifer, and its twin *Y*. On the earth the only well marked triangular bays or straits are the Gulf of California, the Straits of Malacca, and the northern end of the sea of Japan. That six such bays should have been seen on Mars, grouped in three pairs, indicates that there must be some connection between the components. Since the *Y* has long since disappeared, it seems that it is not necessary that the connection should be maintained.

That Propontis and Castorius exactly coincided in position with the canals Hades and Erigone on Antoniadi's map (Flammarion II), leads us to surmise that the frequently recorded duplication of the canals may also be a genuine phenomenon. The difficulty that the writer has always felt regarding it, however, has been that those who saw it, either saw too much, or else other observers saw too little. We have seen by Report No. 11 that one felt uncertain of the separation of two parallel lines with the naked eye when the angular distance between them was reduced to 69″. Schiaparelli discovered the duplication of the canals with an aperture of 8 inches, and it is claimed to have been seen with 6. If the diameter of the pupil of the eye is assumed under ordinary conditions in a well lighted room to be one-eighth of an inch, as for instance when the above recorded separation of the parallel lines was suspected, the separation of the canals when observed with these small apertures should range from at least 1″ to 1″.33. That such obvious separations should not be readily detected with larger apertures, working even under rather unfavorable atmospheric conditions, seems incredible. On account of the lateness of the development of the detail on Mars this season, the assumed duplication will hardly reach its maximum before opposition, so that this year should be extremely favorable for its detection, if it really exists.

Observations in December.

Early in December the deserts were very red, and on the 6th and 10th they were painted to match 14 on the scale. By December 14 they were orange and matched 12. On December 17 and 19 they were still more yellow, with scarcely any cloud visible at the limb. Their color must nearly have reached 11. The next night the disk was seen at a glance to be much redder again, with much cloud on the limb, and also scattered in small areas over the disk. The reading on the color scale was found to be 14. December 25 the color was reduced to 12.5. It thus appears that while the bands that later develop into canals are still broad, and while the main features, such as the bays of Sabaeus and

Margaritifer, are still in the process of forming, the atmosphere of Mars is generally in a pretty hazy condition. It is only when the atmosphere clears that the individual clouds become distinctly visible. While the scale is particularly adapted to the determination of the general color of the desert regions, and their variation from night to night, in order to determine the colors of the individual markings, such as the maria, and the blue and brown spots, another method must be employed. This consists in actually drawing and coloring the disk, and viewing the result through a black mask by a properly colored light. When this has been done, it is found that the maria are not in general really green by white light as our vegetation is, but only grey. That is they match plain pencil shading. On the other hand however, they are decidedly green compared with the desert regions. We therefore conclude that the vegetation is not continuous as with us, but occurs in spots on the red soil, the red and green uniting to produce on our eyes the effect of grey. The northern maria, which we have hitherto described as grey, it now appears have a brownish tint, doubtless that of moistened soil. Observations were secured upon the following dates:—

December 4, ω 173°, M. D. March 46. Owing to previous unfavorable terrestrial atmospheric conditions at this Martian longitude, this was our first view this year of the twin bays of Propontis and Castorius. They were now united into one broad and nearly uniform band, extending from the polar cap to Charontis.

December 6, ω 153° and 190°, M. D. March 48. The individual canals leading from the two bays to Charontis were now just visible, and quite distinct, but the bays themselves were still combined into one. Titanum was distinguishable, but not yet very marked in shape. Definition good, but very little detail.

December 7, ω 174°, M. D. March 49. A cloud 700 miles in length following Charontis was noted within 30° of the central meridian. Earlier it also followed the western canal connecting Charontis with the polar band. The breadth of this band, where preceding Propontis, in longitude 140°, was recorded as follows, in terms of the breadth of the polar cap, showing its gradual broadening as the Martian day progressed. The

TABLE II.

BREADTH OF THE POLAR BAND.

G. M. T.	ω	M. L. T.	Breadth	Miles
h	°	h		
20.7	145	2.6	0.6	300
21.0	150	2.9	0.7	350
22.6	172	4.5	0.8	400
22.8	175	4.7	0.9	450
23.0	178	4.9	1.2	600

third column of the table gives the Martian local solar time for longitude 140°. The rapid increase in breadth towards the end of the observation was in large part due to the proximity of the terminator, which caused the whole region to darken. The four earlier observations are believed to be fairly accurate. The latitude was + 55°.

December 8. The longitude and latitude of the south preceding corner of Castorius were determined, by the method described in Report No. 13 at the time of transitting the central meridian, at 135°.6 and + 43°.

December 10, ω 118°, M. D. March 52. The longitude and latitude of this point were redetermined. Result 137°.5 and + 43°. It will be interesting to see if the longitude increases as the season advances. The latitude was certainly greater than + 39°. It was at first thought that the twin polar bays had begun to separate, but it was concluded later that the effect was only due to a cloud stretching across the dark region. Phoenicis Lacus was faintly seen for the first time this year.

December 14, at ω 72° Solis Lacus was near the central meridian. It had clearly developed, but the seeing was too poor to draw it satifactorily.

December 16, ω 64°, M. D. April 2. The rounding off of the following end of the polar cap towards the limb was distinctly seen for the first time, although the cap still appeared tangent to the limb. A minute cloud was suspected following the Acidalium marsh, and past the central meridian. That is it had lasted well into the Martian afternoon. Solis Lacus could not be distinguished.

December 17, ω 83°, M. D. April 3. The snow cap had materially increased in size. Tithonius and Solis had now both developed.

December 19, ω 66°, M. D. April 5. A very brilliant white area was seen on the southern terminator, just preceding Thaumasia. It appeared whiter and fully as bright as the northern cap. Its latitude was in the vicinity of − 40°. It seems at first rather early for snow in the southern hemisphere, until we look at the calendar and find that it was 61 days after the equinox in their long winter season. Since it was seen just before their sunset, it does not seem likely to have been hoar frost, but as it was not found again the next night, it must have been a very thin layer of snow.

December 20, ω 33°, M. D. April 6. The striking change in color of the disk due to the clearing away of the Martian clouds has already been described. The Acidalium marsh was found to have largely increased in size, its meridional length was now 1000 miles, in place of 600 as on the previous night, and its breadth 800 instead of 600. It was darkest towards the snow, and its color was bluish black. The conspicuous canal Hydraotes visible the previous night had disap-

peared and its place was covered by a white cloud, although it was now as late as two in the afternoon by Martian time in that longitude. Three drawings were made of the snow cap, measuring 16, 15, and 14 millimeters in length. The first and last were obviously too large and too small, indicating that we should expect an accuracy of about one millimeter, or 0″.25, that being the scale on which all our drawings are now made.

December 25, ω 353°, M. D. April 11. The color of the deserts had again assumed an orange tint, indicating that the clearing off observed December 20 was but temporary. Although the Acidalium marsh was distinctly blue, there was no trace of polarization that could be detected. This is unusual, since the blue color and polarization usually go together. The snow cap which had somewhat diminished December 23 had again increased in size. The bay of Sabaeus had begun to develop, although there was no trace of Aryn as yet. Seeing 7 This date is 24 days later than any of the drawings showing Aryn published in Report No. 8. The region which should later develop into the Strait of Sabaeus had narrowed appreciably since our last previous view of it November 19, but the southern boundary was not sharply defined as yet. There was no trace of Margaritifer, although five days earlier a slight projection in that place had been recognized. The broad straight band connecting Acidalium with the Bay of Sabaeus appeared much as it did in November. Except Deuteronilus and Callirrhoe previously recorded, no canals were visible.

It will be recalled that in Report No. 12, on October 23, M.D. March 5, mention is made of the first appearance and formation of the Syrtis marsh this Martian year. On November 19 to 27, M. D. March 32 to 40, it was well seen, but it then appeared not much darker than the surrounding region, and only of moderate size. On December 26, M. D. April 12. At ω 300° the straight band connecting the Syrtis with the polar cap was clearly seen, and it was recorded that the Syrtis might be a little darker at the tip, but certainly there was no extensive marsh there at that time. Seeing 5. With this quality of seeing magnification 330 was clearly preferable to 660. A report has just been received from Professor Douglass of the Associated Observers, who observed it on the nights of November 26 and December 2. He states that the Syrtis seemed to show pretty black in its northern part in a limited area, especially on the second morning, but it did not show at all until within 30° of the central meridian,—"as if emerging from a morning fog." His drawings show a comparatively small dark region about 300 miles in diameter. Neither observer had hitherto detected any blue color in it, and it is doubtful if it contained much water up to

December 26. Professor Douglass' observation corroborates the view that there is still much fog in the Martian atmosphere.

Owing in part to unfavorable atmospheric conditions, and in part to circumstances over which the writer had no control, it was impossible to secure any observations on the last five days of the month. As soon as the telescope was again turned on the planet, January 1, it was at once noted that the Syrtis marsh was strongly developed, of large size and very blue, especially on the preceding side. The southern border was indistinct, but it was evident that a considerable change had occurred since our last observation. Its length and breadth on its southern border were both about 1200 miles. It is to be hoped that the planet has been under observation elsewhere during these five days, and that some one of the Associated Observers will be able to give a detailed account of just what happened, and especially of when the blue color made its first appearance. Three observations and a colored sketch have been sent by Mr. L. J. Wilson, S. P. A. The latter, made upon December 5, ω 135°, shows the Propontis Castorius region as slightly developed and of a bluish color. There is a small cloud on the southern terminator. Extensive color observations have been received from Mr. McEwen made on the nights of October 14, 21, and 30. The second indicated a darkening to the west of the Propontis region, at the edge of the polar cap, near longitude 200°. He also noted a bright area (presumably a cloud) following Charontis. The usual cloud following the Acidalium marsh was recorded in the last observation. He also recorded Tithonius, Ascraeus, Lunae, and Phoenices lakes. Ceraunius was recognized, and suspected of duplicity.

A very interesting private letter has just been received from M. Jarry Desloges, which unfortunately I am not permitted to quote. A few statements of general interest may be culled from it however. He says that although he possesses a telescope of 20 inches aperture, he considers that for planetary work it is useless to use apertures exceeding 13 inches, nor does he favor higher magnifications than 500. He states that excellent atmospheric conditions are found at Setif in northern Africa in the winter time. The altitude is 3600 feet, and two years ago they had 60 inches of snow there for over a month. This statement is of particular interest, since at nearly all the chief observatories of the world, north and south of the equator, the weather is unfavorable during the northern winter months. He carried a large telescope into the desert some 200 miles from the coast but found the conditions there distinctly inferior to those at Setif. This fully confirms our experience in Jamaica, that our best seeing comes on damp nights. He does not agree with the writer and some others that Elysium appeared rounded at the last opposition. An observation by the writer

made early in January indicates a considerable change in size in Elysium, and it is hoped that others will devote especial attention to this marking this year. Those sending colored sketches to the writer should mention the source of light they employ, and also mention if they took the precaution to have the image of the planet and the drawing of the same brightness.

Table III contains the usual data of the month's drawings.

TABLE III.

DATA OF THE DRAWINGS.

No.	1915	⊙	M. D.	Long.	Lat.	Sun	Diam.	Seeing
		°		°	°	°	″	
31	Dec. 4	22.4	Mar. 46	173	+20	+9	9.0	6
32	" 6	23.3	" 48	153	"	"	9.1	8
33	" "	"	" "	190	"	"	"	8
34	" 7	23.8	" 49	153	"	"	9.2	7
35	" "	"	" "	174	"	"	"	6
36	" 10	25.2	" 52	118	"	10	9.5	12
37	" 16	27.9	Apr. 2	64	"	11	10.0	7
38	" 17	28.4	" 3	83	"	"	10.1	7, 6
39	" 19	29.3	" 5	66	"	12	10.3	8, 7
40	" 20	29.8	" 6	33	"	"	10.4	9
41	" 25	31.9	" 11	353	"	"	10.9	7, 6

The following canals and lakes were seen:—

Dec. 4 **D** Cerberus. Lakes: Charontis.

Dec. 6 **D** Cerberus, Hades, Erigone (Antoniadi). Lakes: Charontis.

Dec. 7 **D** Cerberus, Hades, Erigone (A), Titan. Lakes: Charontis.

Dec. 10 **C** Phlegethon, Acheron, Pyriphlegethon (?) Lakes: Phoenicis.

Dec. 16 **B** Nilokeras, Chrysorrhoas, Hydraotes, Jamuna, Ceraunius. Lakes: Lunae, Tithonius.

Dec. 17 **B** Ceraunius, Nectar. Lakes: Lunae, Tithonius, Solis.

Dec. 19 **B** Nilokeras, Hydraotes, Chrysorrhoas, Araxes, Nectar. Lakes: Lunae, Tithonius, Solis.

Dec. 20 **B** Nilokeras, Chrysorrhoas.

Dec. 25 **A** Deuteronilus, Callirrhoe.

CELESTIAL MOTIONS IN THE LINE OF SIGHT.

RUSSELL SULLIVAN.

The spectroscopic study of stellar motion in the line of sight (i.e. the line connecting the star to the observer) has of late made tremendous strides. Although it has been known for some years that stars of advanced spectral type move more swiftly than the earlier types, yet it is only within the last year or two that these studies have been applied with success to the nebulae.

Commencing the scale of cosmic speeds with the great nebula in Orion, we see an increasing series of velocities, as is evident from a glance at the table given below. There is a gap between the type "M" stars and the Planetary Nebulae, although this may be filled by a class of faint swift stars which Eddington has recently described. (The latter have not been investigated spectroscopically). The other gap lies between the Planetary Nebulae and the Spiral Nebulae which have recently been found by Slipher to possess enormous radial velocities. There seems to be no evolutionary step between the spirals and the planetary nebulae, whereas, from the slow type "B" star up to the planetary nebulae there is a fairly continuous series of speeds.

Campbell found an uninterrupted progression of speed through the types B, A, F, G, K, M; the following table shows the progressive increase of cosmic velocity:

TABLE OF COMPARATIVE RADIAL VELOCITIES.

	Average in miles per second	
Great Nebula in Orion	0.66	Keeler
B	3.91	Campbell
A	6.57	"
F	8.62	"
G	8.98	"
K	10.08	"
M	10.26	"
Planetary Nebulae	30.00	"
Spiral Nebulae	240.00	Slipher

If the motion of the great nebula in Orion be represented by a line an inch long, the motion of the spiral nebulae would correspond to a line 30 feet in length.

The great nebula of Orion is generally assumed to represent the beginning of stellar evolution. It is gaseous and almost at rest in space.

Type "B" is the intensely luminous helium (or Orion) star; type "A" is exemplified by Sirius and is usually known as the hydrogen star; type "F" is the Calcium star; the sun belongs to type "G"; type "K" is similar to the solar type, but differs principally in having hydrogen lines fainter than the metallic lines; type "M" is well shown by the ruddy Betelgeuse in whose spectrum titanium oxide predominates—metallic lines and flutings characterize the latter types.

The distribution of the series B, A, F, G, K, M, is confined to the Galactic Plane for the slower types, but is almost globular for the faster types ending with type "M". The irregular and planetary nebulae tend to lie in or near the plane of the Milky Way, (the latter class so called because of their resemblance to the disk of a planet). Both types are gaseous but on account of the great difference in speed they appear to belong to opposite ends of the scale of evolution. The speed of the planetary nebulae argues a stellar origin for these bodies, as suggested by Campbell. The spirals belong to the non-gaseous type and give a continuous spectrum, implying the existence of solid matter or gas under great pressure.

The spirals tend to crowd towards the poles of the Milky Way. Slipher found that they belong to the G-K types of spectrum—similar to that of the sun, and rather late in the evolutionary scale.

The vast gap between the planetaries and the spirals almost tempts one to believe in the existence of a different cosmic order; before the spectroscope had shown the difference in nebulae, the majority of astronomers believed that the spirals were "island universes"; among recent writers, Poincaré, Puiseux, Russell and Eddington have suggested that the spirals are distant sidereal universes.

Recent measures of radial velocities by Ralph E. Wilson on the Lick Observatory plates on four gaseous nebulae in the Greater Magellanic Cloud indicate great and nearly equal speeds, and it is fair to assume that the Greater Cloud as a whole is in very rapid motion. Thus it is easier to credit the spiral nebulae with enormous velocities.

Slipher finds that the greater component of motion is parallel to the plane in which the arms of the spiral lie; so the spirals would tend to move edge-on through space, and appear to follow the line of least resistance. (The plane of the solar system exhibits a similar tendency to move edgewise through space, towards the sun's distant goal). Eddington and Easton think that the Milky Way includes the arms of a gigantic spiral and thus we can infer that our own universe is moving at great speed, as Poincaré has suggested, principally in the plane of the Milky Way; as the sun lies in or near the plane of the Milky Way, we are living in the nucleus of a spiral nebula.

Slipher's results also indicate that the spirals measured north of the Milky Way were receding at great speed, but south of the Milky Way, the few measured (with some exceptions) were approaching. Before noting the exceptions, he suggested that this was a drift of the spirals across the Milky Way from south to north; perhaps it can be interpreted as a drift of the Milky Way from north to south. Poincaré suggested that the spirals be observed for motions at right angles to the line of sight to detect a possible rotation of the Milky Way. This method would have taken centuries. It seems that his plan is being executed in a new and unexpected way.

The idea of external "island universes" as held by the older astronomers of the last century, is again in favor—this time with the spectroscopic evidence of speeds surpassing the wildest dreams of the old school.

THE MOTIONS OF THE SPIRAL NEBULAE.

O. H. TRUMAN.

I have lately been considerably concerned about the question as to whether the spiral nebulae are other sidereal universes. The admirable way in which that hypothesis would account for their vanishingly small parallaxes and proper motions, for their luminosity, and for their distribution in the sky makes it very attractive, and the only evidence against it, and that, I think, not conclusive, is the fact that some of them show pure, or almost pure, types of spectra.

Now if they are other sidereal systems, it seems likely that a distinct motion of our own spiral nebula with respect to them would manifest itself, and conversely, if we can find such a motion of our system with respect to the nebula, it will be quite strongly urged upon us that they are other sidereal systems. This has already been remarked upon by H. Spencer Jones. And inasmuch as we already have radial velocities of upwards of a dozen, in different parts of the sky, determined by V. M. Slipher and published in POPULAR ASTRONOMY, Vol. 23, page 23, January 1915, and Herschel discovered the solar motion with about that number of stars, it seems time to investigate.

So from that list I have taken N. G. C. 221 and N. G. C. 224, the Andromeda nebula and companion, as one nebula, as their equal radial velocities, — 300 km / sec, should remove any residual doubt that they belong together; N. G. C. 3031 and 4826, whose velocities Slipher gives

as "Plus, small" I have given velocities of plus 100 km / sec; and N. G. C. 5195, whose velocity he gives as "± Small," I have given a velocity of zero. I do not know whether his velocities are corrected for solar motion or not, but the corrections would be comparatively insignificant, so that makes no difference in the results.

The list may now be solved out by least squares in the usual way, such as is described, for instance, in Campbell's "Stellar Motions," p. 170, and one obtains as the components of velocity of the center of position of the group:

$$x = -340 \text{ km / sec} \pm 145$$
$$y = +530 \text{ km / sec} \pm 320$$
$$z = +230 \text{ km / sec} \pm 190.$$

where, of course, x is in R. A. $0^h\ 0^m$, Dec. 0°, y in R.A. 6^h Dec. 0°, and z is at the north pole.

It appears that the ratios of the quantities determined to their probable errors are 2.3, 1.7, and 1.2, respectively, which is quite encouraging, and, I think, points quite strongly to the reality of the results.

The direction determined by the above quantities is the apex of the nebulas' motion, and the antapex of our motion. It turns out, according to this, that our nebula is moving with a velocity of 670 km /sec in the direction of R. A. 20 hrs. Dec. $-20°$. This is a point between Sagittarius and Capricorn, about 60 degrees from Pickering's pole of the Galaxy, and while that does not come as near being in the plane of the Galaxy as might be desired, yet it comes as close as could reasonably be expected from a first trial. One wonders whether there is not something in Slipher's conjecture that the spiral nebulae move edgewise.

I think the determination of radial velocities of spiral nebulae should be vigorously pursued, in order to quickly find out whether the above results are indeed real.

University of Iowa.
Dec. 30, 1915.

THE STARRY SICKLE.

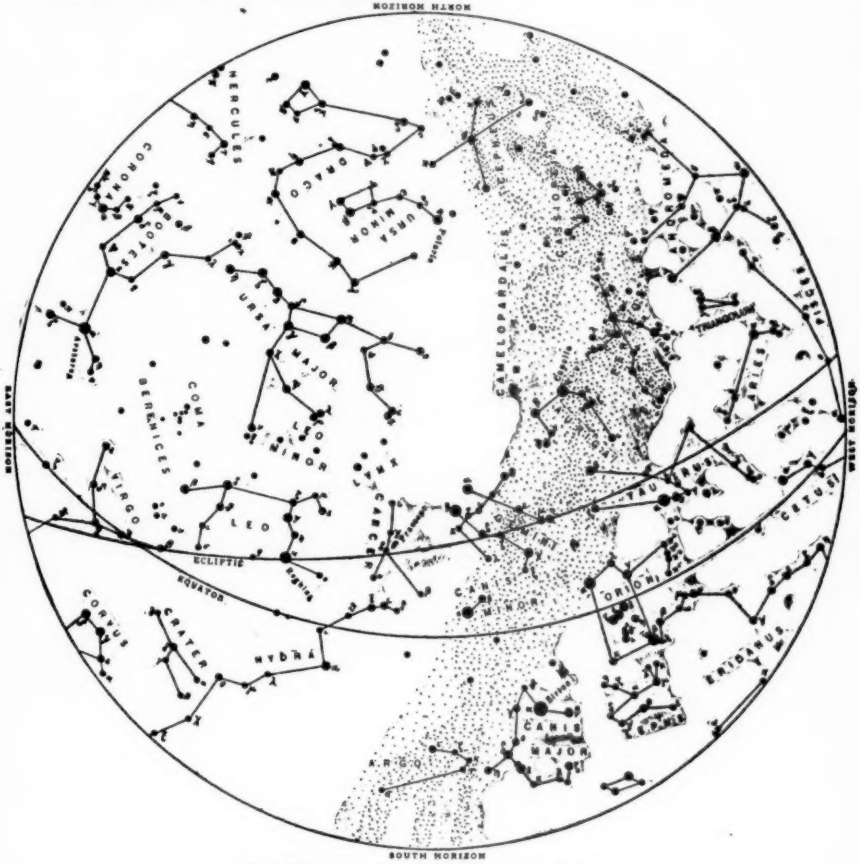
Where Leo waits King Sol in dog-days' reign
And Regulus shines diamond-like and bright,
When springtime wakes and summer smiles again
Till harvest moon beams mellow in the night;
Six suns, with four stars sparkling in its train,
Like question-mark which faces to the right.
Or secret symbol written clear and plain,
A starry sickle glttters in men's sight.

CHARLES NEVERS HOLMES.

Hotel Nottingham, Boston.

PLANET NOTES FOR MARCH, 1916.

The sun will move from 7° 36′ south of the equator to 4° 8′ north of the equator during the month of March. It will cross the equator on March 20. At the time of crossing the equator the right ascension of the sun will be $0^h\ 0^m\ 0^s$, as this is the point from which right ascension is measured. This is the date of the vernal equinox, the date of the beginning of spring.



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

The phases of the moon for this month are as follows:

New Moon	Mar. 3	at	10 P.M.	C.S.T.
First Quarter	11	"	1 P.M.	"
Full Moon	19	"	11 A.M.	"
Last Quarter	26	"	10 A.M.	"

The moon will be at its farthest point from the earth for the month on March 12, and nearest on March 26.

Mercury will be at a point of greatest elongation west of the sun on the first day of the month. It will then be visible in the morning sky. It will be visible during the greater part of the month but will gradually be approaching the sun.

Venus will continue to be the brilliant and conspicuous object in the evening sky throughout the month. It will be a few degrees north and two and a half hours east of the sun. It will be approaching the earth throughout the month. Its average distance from the earth for the month will be about the mean distance from the earth to the sun.

Mars, having just passed a point of opposition, will be favorably situated during this month. It will cross the meridian about nine o'clock in the evening. It will however again be receding from the earth.

Jupiter will scarcely be within reach of observation at all during March. It will be found low in the twilight at sunset at the beginning of the month, and about the middle of the month will be lost in the rays of the sun.

Saturn will be moving westward at the beginning of the month but will turn and move eastward on March 12. It will be in quadrature with the sun, 90° east, on March 30. It will therefore be on the meridian about sunset.

Uranus will be visible in the early morning. It will rise a few hours before the sun.

Neptune will be a short distance northeast of Saturn. It will also therefore be favorably situated for observation. It will have retrograde motion during this month.

Occultations Visible at Washington.

Date 1916	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
Mar. 7	47 B Arietis	6.5	8 5	103	9 0	328	0 55
11	112 B Aurigae	5.7	7 24	28	7 57	346	0 33
16	18 Leonis	5.8	4 54	83	5 53	324	0 59
16	19 Leonis	6.4	5 33	112	6 45	299	1 12
16	R Leonis(var.)	5-10	5 48	138	6 55	273	1 7
18	359 B Leonis	6.3	7 9	60	7 40	5	0 31
23	π Scorpii	3.0	12 9	162	12 50	240	0 42
23	65 B Scorpii	5.5	16 54	64	18 1	312	1 7
24	95 G Ophiuchi	6.1	17 33	101	18 33	258	1 20
25	66 B Sagittarii	4.7	18 5	73	19 26	266	1 21
26	ψ Sagittarii	4.9	15 36	154	15 59	191	0 23

Saturn's Satellites for March, 1916.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

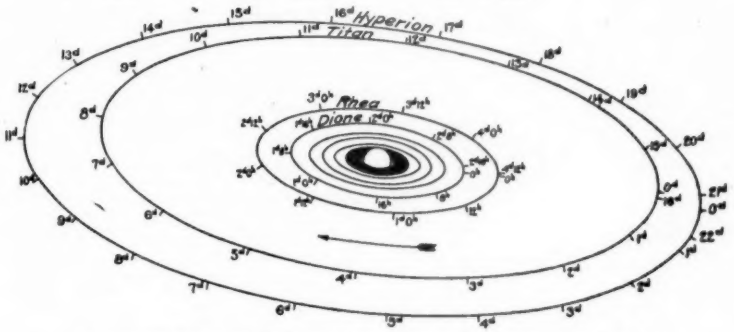
I. Mimas. Period $0^d\ 22^h.6$.

	d	h		h	d		d	h		d	h
Mar.	2	19.9 W	Mar.	8	11.6 W	Mar.	15	13.3 E	Mar.	23	13.5 W
	3	18.6 W		10	20.2 E		16	11.9 E		24	12.2 W
	4	17.2 W		11	18.8 E		19	19.1 W		27	19.4 E
	5	15.8 W		12	17.4 E		20	17.7 W		28	18.0 E
	6	14.4 W		13	16.0 E		21	16.3 W		29	16.6 E
	7	13.0 W		14	14.7 E		22	14.9 W		30	15.3 E
										31	13.9 E

Saturn's Satellites for March, 1916—Continued.

II. Enceladus. Period $1^d\ 8^h.9$.

	d	h		d	h		d	h		d	h
Mar.	1	7.1 E	Mar.	9	12.4 E	Mar.	17	17.7 E	Mar.	25	23.1 E
	2	16.0 E		10	21.3 E		19	2.6 E		27	8.0 E
	4	0.8 E		12	6.2 E		20	11.5 E		28	16.9 E
	5	9.7 E		13	15.1 E		21	20.4 E		30	1.8 E
	6	18.6 E		14	23.9 E		23	5.3 E		31	10.6 E
	8	3.5 E		16	8.8 E		24	14.2 E			



Apparent Orbits of the Seven Inner Satellites of Saturn, at date of Opposition, January 4, 1916, as seen in an Inverting Telescope.

III. Tethys. Period $1^d\ 21^h.3$.

Mar.	1	5.1 E	Mar.	8	18.3 E	Mar.	16	7.6 E	Mar.	23	20.8 E
	3	2.4 E		10	15.6 E		18	4.9 E		25	18.1 E
	4	23.7 E		12	12.9 E		20	2.2 E		27	15.5 E
	6	21.0 E		14	10.3 E		21	23.5 E		29	12.8 E
										31	10.1 E

IV. Dione. Period $2^d\ 17^h.7$.

Mar.	3	6.7 E	Mar.	11	11.8 E	Mar.	19	16.8 E	Mar.	27	21.9 E
	6	0.4 E		14	5.4 E		22	10.5 E		30	15.6 E
	8	18.1 E		16	23.1 E		25	4.2 E			

V. Rhea. $4^d\ 12^h.5$.

Mar.	2	12.6 E	Mar.	11	13.4 E	Mar.	20	14.2 E	Mar.	29	15.2 E
	7	1.0 E		16	1.8 E		25	2.6 E			

VI. Titan. Period $15^d\ 23^h.3$.

Mar.	1	2.9 W	Mar.	9	9.1 E	Mar.	17	1.6 W	Mar.	25	8.0 E

VII. Hyperion. Period $21^d\ 7^h.6$.

Mar.	2	15.4 W	Mar.	12	7.7 E	Mar.	24	1.0 W			

VIII. Japetus. Period $79^d\ 22^h.1$.

Mar. 15 5.4 I

IV. Phoebe. Period $523^d\ 15^h.6$.

		α Ph. — α Sat.	δ Ph. — δ Sat.			α Ph. — α Sat.	δ Ph. — δ Sat.
		m s	′ ″			m s	′ ″
Mar.	1	−0 33.2	+3 2	Mar.	17	−0 54.2	+2 49
	3	0 35.9	3 0		19	0 56.7	2 47
	5	0 38.6	2 58		21	0 59.2	2 46
	7	0 41.2	2 57		23	1 1.7	2 44
	9	0 43.8	2 55		25	1 4.2	2 43
	11	0 46.4	2 54		27	1 6.6	2 42
	13	0 49.0	2 52		29	1 9.0	2 40
	15	−0 51.6	+2 50		31	−1 11.4	+2 39

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1916.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900 h m	Decl. 1900 ° ′	Magn.
X Androm.	0 10.8	+46 27	<14.0	T Leporis	5 0.6	−22 2	8.4
T Androm.	17.2	+26 26	11.3*d*	V Orionis	0.8	+ 3 58	10.0 *i*
T Cassiop.	17.8	+55 14	8.8 *i*	R Aurigae	9.2	+53 28	13.8
R Androm.	18.8	+38 1	14.0*d*	W Aurigae	20.1	+36 49	13.0
S Ceti	19.0	− 9 53	9.5*d*	S Aurigae	20.5	+34 4	9.2
Y Cephei	31.3	+79 48	9.2	S Orionis	24.1	− 4 46	8.8*d*
U Cassiop.	40.8	+47 43	11.6*d*	S Camelop.	30.2	+68 45	9.2*d*
RW Androm.	41.9	+32 8	14.0	T Orionis	30.9	− 5 32	9.8
V Androm.	44.6	+35 6	9.2	U Aurigae	35.6	+31 59	13.2*d*
RR Androm.	45.9	+33 50	12.5*d*	SU Tauri	43.2	+19 2	10.2
RV Cassiop	47.1	+46 53	11.5*d*	Z Tauri	46.7	+15 46	<13.0
W Cassiop.	49.0	+58 1	12.3	RU Tauri	46.9	+15 57	<13.0
Z Ceti	1 1.6	− 2 1	13.0	V Camelop.	49.4	+74 30	8.3
U Androm.	9.8	+40 11	10.0 *i*	U Orionis	49.9	+20 10	11.8*d*
S Cassiop.	12.3	+72 5	14.0*d*	Z Aurigae	53.6	+53 18	10.5*d*
S Piscium	12.4	+ 8 24	9.5 *i*	X Aurigae	6 4.4	+50 15	8.7
U Piscium	17.7	+12 21	10.8 *i*	SS Aurigae	5.8	+47 46	<14.0
RZ Persei	23.6	+50 20	13.2*d*	V Aurigae	16.5	+47 45	9.5
R Piscium	25.5	+ 2 22	9.9*d*	V Monoc.	17.7	− 2 9	7.0
RU Androm.	32.8	+38 10	12.5*d*	U Lyncis	31.8	+59 57	14.0
Y Androm.	33.7	+38 50	13.0*d*	S Lyncis	35.9	+58 0	9.1 *i*
X Cassiop.	49.8	+58 46	12.0	Y Monoc.	51.3	+11 22	9.0 *i*
U Persei	53.0	+54 20	8.2 *i*	X Monoc.	52.4	− 8 56	9.0*d*
S Arietis	59.3	+12 3	13.0 *i*	R Lyncis	53.0	+55 28	8.8 *i*
R Arietis	2 10.4	+24 35	12.4	R Geminorum	7 1.3	+22 52	9.1*d*
W Androm.	11.2	+43 50	14.0	V Can. Min.	1.5	+ 9 2	10.2*d*
Z Cephei	12.8	+81 13	<13.5	R Can. Min.	3.2	+10 11	10.2*d*
o Ceti	14.3	− 3 26	3.1	RR Monoc.	12.4	+ 1 17	<13.0
S Persei	15.7	+58 8	8.8 *i*	S Can. Min.	27.3	+ 8 32	7.3 *i*
R Ceti	20.9	− 0 38	8.0 *i*	Z Puppis	28.3	−20 27	13.2
RR Persei	21.7	+50 49	12.2*d*	T Can. Min.	28.4	+11 58	9.2
U Ceti	28.9	−13 35	10.3*d*	U Can. Min.	35.9	+ 8 37	9.5
RR Cephei	29.4	+80 42	13.7	S Geminorum	37.0	+23 41	<13.0
R Trianguli	31.0	+33 50	9.0 *i*	T Geminorum	43.3	+23 59	9.8*d*
W Persei	43.2	+56 34	10.7*d*	U Puppis	56.1	−12 34	14.0
U Arietis	3 5.5	+14 25	13.0 *i*	R Cancri	8 11.0	+12 2	10.4 *i*
X Ceti	14.3	− 1 26	9.3*d*	V Cancri	16.0	+17 36	9.0 *i*
Y Persei	20.9	+43 50	10.0*d*	RT Hydrae	24.7	− 5 59	9.0*d*
R Persei	23.7	+35 20	12.8*d*	U Cancri	30.0	+19 14	12.0*d*
Nov. Per. No. 2	24.4	+43 34	13.5*d*	S Hydrae	48.4	+ 3 27	7.8 *i*
W Tauri	4 22.2	+15 49	9.8 *i*	T Hydrae	50.8	− 8 46	8.4
R Tauri	22.8	+ 9 56	14.0*d*	T Cancri	51.0	+20 14	8.8
S Tauri	23.7	+ 9 44	14.0	S Pyxidis	9 0.7	−24 41	9.5 *i*
T Camelop.	30.4	+65 57	13.8	W Cancri	4.0	+25 39	14.0
X Camelop.	32.6	+74 56	9.0	X Hydrae	30.7	−14 15	11.0
RX Tauri	32.8	+ 8 9	12.3*d*	Y Draconis	31.1	+78 18	<13.5
V Tauri	46.2	+17 22	9.8 *i*	R Leo. Min.	39.6	+34 58	7.7 *i*
R Orionis	53.6	+ 7 59	13.3	RR Hydrae	40.4	−23 34	13.8
R Leporis	55.0	−14 57	7.5	R Leonis	42.2	+11 54	6.8*d*

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1916—Continued.

Name.	R. A. 1900. h m	Decl. 1900 ° ′	Magn.	Name.	R. A. 1900. h m	Decl. 1900 ° ′	Magn.
Y Hydrae	9 46.4	−22 33	6.8	R Aquilae	19 1.6	+ 8 5	9.5*d*
V Leonis	54.5	+21 44	9.0	V Lyrae	5.2	+29 30	<14.0
R Urs. Maj.	10 37.6	+69 18	7.0	RU Lyrae	9.1	+41 8	12.7*d*
V Hydrae	46.8	−20 43	7.4	S Lyrae	9.1	+25 50	<14.0
W Leonis	48.4	+14 15	11.0*d*	RS Lyrae	9.3	+33 15	<14.5
S Leonis	11 5.7	+ 6 0	10.6 *i*	U Draconis	9.9	+67 7	10.5 *i*
R Com. Ber.	59.1	+19 20	14.2*d*	TZ Cygni	13.4	+50 0	10.8*d*
SU Virginis	12 0.0	+12 56	12.4	U Lyrae	16.6	+37 42	11.8 *i*
T Virginis	9.5	− 5 29	13.8	TY Cygni	29.8	+28 6	11.4 *i*
R Corvi	14.4	−18 42	11.8 *i*	RT Aquilae	33.3	+11 30	13.8
SS Virginis	20.1	+ 1 19	7.0	R Cygni	34.1	+49 58	12.0*d*
T Can. Ven.	25.2	+32 3	12.0	RV Aquilae	35.9	+ 9 42	13.0*d*
Y Virginis	28.7	− 3 52	10.8 *i*	RT Cygni	40.8	+48 32	10.7*d*
T Urs. Maj.	31.8	+60 2	10.8*d*	TU Cygni	43.3	+48 49	10.8*d*
R Virginis	33.4	+ 7 32	7.8 *i*	X Aquilae	46.5	+ 4 13	<13.0
RS Urs. Maj.	34.4	+59 2	8.0 *i*	χ Cygni	46.7	+32 40	6.8 *i*
S Urs. Maj.	39.6	+61 38	8.6	Z Cygni	58.6	+49 46	8.7 *i*
RU Virginis	42.2	+ 4 42	12.5*d*	S Cygni	20 3.4	+57 42	10.3 *i*
U Virginis	46.0	+ 6 6	12.8*d*	S Aquilae	7.0	+15 19	8.2
V Virginis	13 22.6	− 2 39	<13.0	RU Aquilae	8.0	+12 42	11.5*d*
S Virginis	27.8	− 6 41	8.0 *i*	RS Cygni	9.8	+38 28	7.4
T Urs. Min.	32.6	+73 56	12.2*d*	R Delphini	10.1	+ 8 47	13.4*d*
R Can. Ven.	44.6	+40 2	7.8 *i*	SX Cygni	11.6	+30 46	<14.0
U Urs. Min.	14 15.1	+67 15	8.2	U Cygni	16.5	+47 35	7.0
S Bootis	19.5	+54 16	11.5*d*	Z Delphini	28.1	+17 7	14.0*d*
R Camelop.	25.1	+84 17	12.2*d*	ST Cygni	29.9	+54 38	12.8*d*
V Bootis	25.7	+39 18	7.4 *i*	Y Delphini	36.9	+11 31	13.6*d*
S Urs. Min.	15 33.4	+78 58	12.0	V Cygni	38.1	+47 47	9.4*d*
R Cor.Bor.	44.4	+28 28	6.3	S Delphini	38.5	+16 44	10.0 *i*
X Cor. Bor.	45.2	+36 35	10.0*d*	Y Aquarii	39.2	− 5 12	<13.0
V Cor. Bor.	46.0	+39 52	8.5	T Delphini	40.7	+16 2	13.6*d*
R Herculis	16 1.7	+18 38	10.0 *i*	W Aquarii	41.2	− 4 27	9.0 *i*
W Cor. Bor.	11.8	+38 3	8.0	V Delphini	43.2	+18 58	11.4*d*
U Herculis	21.4	+19 7	12.0	T Aquarii	44.7	− 5 31	12.8*d*
SS Herculis	28.0	+ 7 3	9.2	RZ Cygni	48.5	+46 59	11.7*d*
R Urs. Min.	31.3	+72 28	9.4	X Delphini	50.3	+17 16	13.4*d*
R Draconis	32.4	+66 58	12.0*d*	R Vulpeculae	59.9	+23 26	8.4
RV Herculis	56.8	+31 22	<14.0	TW Cygni	21 1.8	+29 0	<13.5
RT Herculis	17 6.8	+27 11	13.8*d*	X Cephei	3.6	+82 40	11.5*d*
RS Herculis	17.5	+23 1	10.2*d*	RS Aquarii	5.8	− 4 27	11.7 *i*
T Draconis	54.8	+58 14	10.4	T Cephei	8.2	+68 5	6.4
V Draconis	56.3	+54 53	9.8	R Equulei	8.4	+12 23	12.2*d*
T Herculis	18 5.3	+31 0	8.5 *i*	RR Aquarii	9.8	− 3 19	<13.0
W Draconis	5.4	+65 56	9.3	X Pegasi	16.3	+14 2	14.0
X Draconis	6.8	+66 8	10.5 *i*	S Cephei	36.5	+78 10	9.6 *i*
W Lyrae	11.5	+36 38	9.3 *i*	RU Cygni	37.3	+53 52	8.5
SV Herculis	22.3	+24 58	11.3*d*	SS Cygni	38.8	+43 8	10.4*d*
T Serpentis	23.9	+ 6 14	<13.5	RR Pegasi	40.0	+24 33	<14.0
SV Draconis	31.2	+49 18	13.6	V Pegasi	56.0	+ 5 38	12.8
RZ Herculis	32.7	+25 58	12.2*d*	RT Pegasi	59.8	+34 38	12.6*d*
RY Lyrae	41.2	+34 34	11.3 *i*	T Pegasi	22 4.0	+12 3	<13.5
RW Lyrae	42.1	+43 32	12.4*d*	Y Pegasi	6.8	+13 52	13.8 *i*
RX Lyrae	50.4	+32 42	13.8	RS Pegasi	7.4	+14 4	9.0
Z Lyrae	56.0	+34 49	13.8	RV Pegasi	21.0	+29 58	<13.0
RT Lyrae	57.8	+37 22	13.4	S Lacertae	24.6	+39 48	12.2*d*

Approximate Magnitudes of Variable Stars of Long Period on Jan. 1, 1916—Continued.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Decl. 1900. ° ′	Magn.
R Lacertae	22 38.8	+41 51	10.1*d*	R Aquarii	23 38.6	−15 50	9.4*d*
S Aquarii	51.8	−20 53	9.8*d*	Z Cassiop.	39.7	+56 2	14.0
RW Pegasi	59.2	+14 46	9.0 *i*	RR Cassiop.	50.7	+53 8	11.6 *i*
R Pegasi	23 1.6	+10 0	7.3	V Ceti	52.8	− 9 31	9.8 *i*
V Cassiop.	7.4	+59 8	10.7*d*	R Cassiop.	53.3	+50 50	7.8*d*
W Pegasi	14.8	+25 44	12.0	Z Pegasi	55.0	+25 21	8.7 *i*
S Pegasi	15.5	+ 8 22	13.8*d*	Y Cassiop	58.2	+55 7	14.0
Z Androm.	28.8	+48 16	10.8	SV Androm.	59.2	+39 33	13.0
ST Androm.	33.8	+35 13	11.2*d*				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, G. L. Harrell, W. P. Hoge, S. C. Hunter, J. B. Lacchini, C. B. Lindsley, O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, D. B. Pickering, C. F. Richter, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young

Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in 1916. March d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7		24 3			
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	8 12;	16 15;	24 18;	28 20	
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 5;	14 22;	22 16;	30 10	
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	2 7;	17 2;	31 22		
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 0;	9 22;	17 21;	25 19	
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	1 3;	8 22;	16 17;	24 13	
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	1 3;	8 10;	15 16;	22 23	
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	6 0;	19 0			
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	2 19;	11 9;	19 23;	28 13	
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	1 13;	12 16;	23 19		
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	8 11;	20 2;	31 17		
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	1 7;	8 23;	16 15;	24 7	
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	2 4;	12 8;	22 11		
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	8 7;	16 0;	23 17;	31 11	
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	4 20;	10 9;	15 21;	21 10	
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	7 12;	15 1;	22 15;	30 5	
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	1 17;	28 18			
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	7 12;	14 17;	21 22;	29 3	
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	6 1;	13 23;	21 21;	29 19	
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 10;	13 14;	23 17		
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		15 6			
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	8 5;	16 4;	24 2;	28 1	

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	2 4;	8 21;	15 13;	22 6				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	10 3;	19 10;	24 1;	28 16				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	8 2;	16 20;	21 5;	25 14				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0				29 0				
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	2 1;	8 20;	15 15;	22 9				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2 12;	9 2;	15 17;	22 17				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	6 15;	16 6;	25 22					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 20;	10 19;	18 18;	26 18				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	2 17;	9 11;	16 5;	22 22				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4 23;	10 19;	16 15;	22 11				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	3 19;	8 12;	17 21;	27 6				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	6 7;	23 13						
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	6 10;	14 14;	22 19;	31 0				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 13;	13 14;	20 14;	27 15				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	3 16;	11 21;	20 3;	28 8				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 0;	8 12;	19 12;	30 12				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	6 16;	14 6;	21 19;	29 8				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	4 8;	11 18;	19 4;	26 14				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	2 21;	9 15;	16 10;	23 5				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	6 4;	12 12;	18 20;	25 4				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	6 17;	16 11;	26 5					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	1 5;	10 2;	18 22;	27 19				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	1 13;	7 15;	13 16;	25 19				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 22;	14 22;	21 22;	28 22				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		12 13;	29 16					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	1 14;	9 5;	16 19;	24 9				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	2 4;	7 23;	13 17;	25 6				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	1 9;	8 3;	14 21;	21 15				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	9 1;	18 9;	29 17					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	6 23;	12 23;	19 0;	25 1				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	5 21;	12 1;	18 4;	24 7				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	5 22;	11 21;	17 20;	23 19				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	6 19;	15 22;	25 0					
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	7 22;	14 23;	22 23;	30 0				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	1 6;	8 6;	15 6;	29 6				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	4 10;	12 10;	20 9;	28 9				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	1 23;	9 16;	17 8;	25 1				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	4 3;	11 8;	18 12;	25 16				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	6 12;	14 22;	23 6;	31 15				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3 21;	10 5;	16 13;	22 20				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		16 12						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 14;	6 0;	14 21;	28 4				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	3 14;	10 7;	17 1;	23 18				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	2 22;	9 15;	16 8;	29 18				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	6 0;	20 17						
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	6 8;	14 4;	22 1;	29 21				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	3 12;	10 9;	17 7;	24 4				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	5 9;	10 6;	15 3;	24 20				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	6 0;	14 16;	23 8;	31 23				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 16;	9 1;	14 10;	25 4				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1		11 8;	22 5					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	1 10;	7 20;	14 6;	20 16				
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	3 23;	8 23;	13 22;	23 21				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	3 8;	8 18;	19 15;	30 12				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 1;	11 8;	17 16;	23 23				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	1 14;	13 18;	25 21					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	3 14;	8 14;	18 13;	28 13				

Minima of Variable Stars of Short Period.

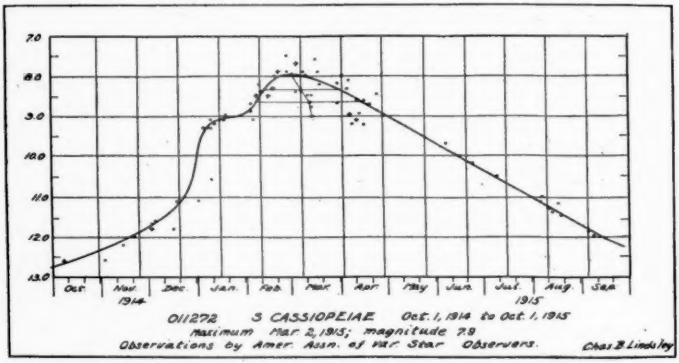
[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

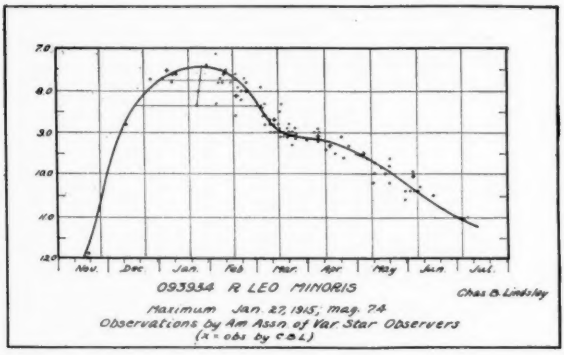
Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1916 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			15 4					
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	3 13;	11 5;	18 21;	26 13				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	4 4;	11 14;	19 1;	26 11				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 14;	15 1;	22 13;	30 10				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	7 14;	13 17;	19 20;	25 22				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	3 7;	10 10;	24 17;	31 21				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 20;	11 17;	18 13;	25 10				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 5;	13 10;	20 14;	27 18				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	8 14;	17 8;	26 3					
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	3 18;	11 17;	19 15;	27 14				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6		15 14						
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	5 3;	10 21;	22 8;	28 1				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	4 6;	11 1;	24 15;	31 10				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	6 17;	14 14;	22 12;	30 10				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	7 21;	16 5;	24 12					
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 17;	11 11;	19 12;	27 9				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	5 20;	19 1						
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	5 0;	14 11;	23 21					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	5 14;	18 0;	30 10					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	2 1;	8 17;	22 1;	28 17				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	3 6;	14 3;	25 1;	30 12				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	1 14;	7 14;	19 15;	31 16				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	5 6;	13 22;	22 14;	31 6				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9		16 17;	27 3					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	7 10;	15 10;	23 11;	31 11				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	1 14;	7 8;	18 19;	30 6				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	3 5;	8 19;	20 0;	31 5				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	8 7;	16 12;	24 17					
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5 14;	13 5;	20 20;	28 11				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	1 10;	13 15;	25 20					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	4 15;	11 19;	18 23;	26 3				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	5 18;	14 21;	23 23					
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	3 9;	12 16;	22 0;	31 7				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	5 13;	14 11;	24 9					
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	8 24;	17 10;	25 20					
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1 17;	8 4;	14 14					
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	3 9;	10 16;	17 22;	25 5				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	1 5;	9 7;	17 10;	25 3				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	4 18;	14 5;	23 17					
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	5 10;	14 13;	23 16					
S Antliae	27.9	−28 11	6.7— 7.3	0 07.8	3 22;	10 10;	23 9;	29 21				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	2 2;	7 23;	19 21;	31 18				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	6 11;	14 21;	23 8;	31 18				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	4 14;	13 21;	23 3					
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	4 1;	10 15;	23 20;	30 11				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	7 14;	16 10;	25 5					
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	6 9;	13 17;	21 1;	28 9				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	4 0;	10 19;	23 9;	30 4				
RZ Centauri	12 55.6	− 64 05	8.5— 8.9	1 21.0	6 6;	13 18;	21 7;	28 19				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	7 18;	17 9;	26 23					
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	6 0;	13 10;	20 20;	28 7				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	2 7;	9 6;	23 5;	30 5				

Minima of Variable Stars of Short Period—Continued.

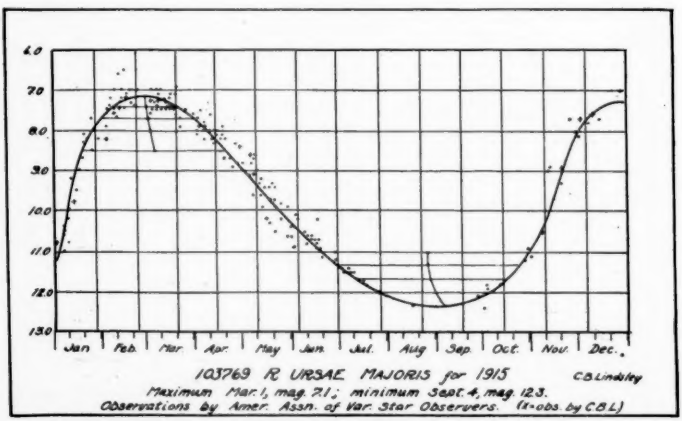
Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1916 March							
	h m	° ′		d h	d	h	d	h	d	h	d	h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	2	4;	9	1;	22	21;	29	19
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	4	4;	12	14;	21	1;	29	11
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	2	8;	10	0;	17	16;	25	7
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	7	2;	14	10;	21	18;	29	2
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	5	23;	14	5;	22	11;	30	17
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	5	9;	14	6;	23	2;	31	23
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	1	15;	11	8;	22	9		
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	7	19;	14	14;	21	10;	28	5
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	7	5;	15	14;	23	23		
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	4	15;	10	19;	23	2;	29	6
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	5	8;	12	13;	19	18;	26	23
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3	3;	10	12;	17	21;	25	6
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1	23;	10	3;	18	8;	26	12
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	6	12;	14	1;	21	14;	29	3
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	8	5;	15	23;	23	17;	31	11
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	1	3;	9	3;	17	3;	25	2
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	4	5;	12	17;	21	6;	29	18
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	5	14;	14	22;	24	6		
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	4	20;	14	4;	24	12		
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	6	12;	13	18;	20	23;	28	5
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	6	12;	13	9;	20	7;	27	5
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	2	5;	17	18				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	7	1;	15	7;	23	14;	31	20
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	1	23;	10	20;	19	17;	28	15
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	7	20;	16	4;	24	11		
RR Draconis	40.8	+62 34	9.3—13	2 19.9	1	22;	10	9;	18	20;	27	7
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2	1;	8	17;	22	0;	28	15
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8			11	9;	24	7		
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	9	15;	19	5;	28	18		
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4	4;	11	18;	19	7;	26	21
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4			11	8;	18	13;	25	18
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	5	17;	14	15;	23	14		
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	3	20;	10	14;	24	3;	30	21
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	1	9;	8	18;	23	11;	30	20
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	5	16;	10	21;	21	9;	31	20
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	3	4;	9	17;	22	18;	29	6
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	5	10;	11	10;	23	10;	29	10
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	6	9;	13	0;	19	16;	26	7
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	1	22;	11	1;	20	5;	29	8
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	3	7;	11	17;	20	4;	28	14
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	2	21;	9	16;	23	5;	30	0
UW Cygni	19.6	+42 55	10.5—13	3 10.8	6	0;	12	21;	19	20;	26	17
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0			23	5				
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	9	18;	19	9;	29	0		
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	2	14;	11	19;	21	0		
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	1	4;	8	15;	23	15;	31	3
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	4	7;	10	4;	21	20;	27	16
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2			10	18;	20	21;	30	23
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	3	7;	10	16;	18	1;	25	10
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	5	9;	15	1;	24	7		
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	5	13;	13	10;	21	7;	29	3
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3			17	5				
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2	23;	13	3;	23	6		
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5	9;	10	13;	20	22;	31	7
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	5	15;	11	2;	21	23;	27	10
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	8	20;	17	3;	25	10		
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	4	12;	12	0;	19	13;	27	2
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	6	8;	14	14;	22	20;	31	2



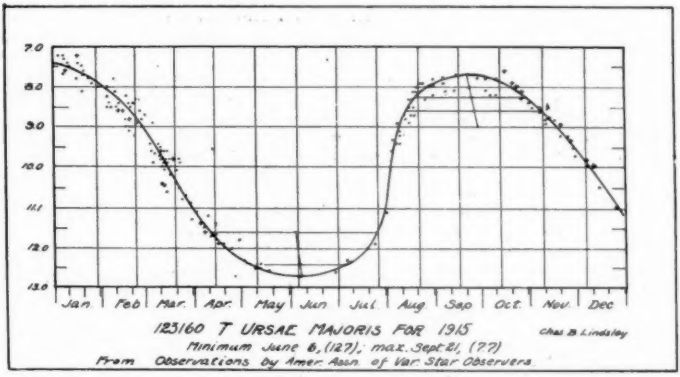
011272 S CASSIOPEIAE Oct. 1, 1914 to Oct. 1, 1915
Maximum Mar. 2, 1915; magnitude 7.8
Observations by Amer. Assn. of Var. Star Observers. Chas B. Lindsley

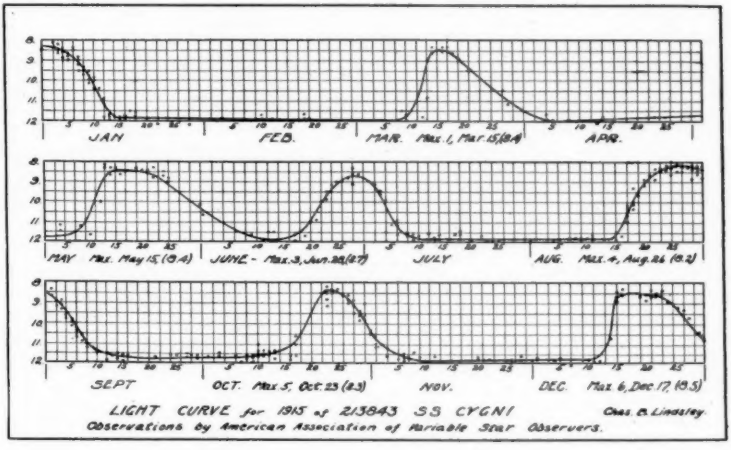


093934 R LEO MINORIS Chas B. Lindsley
Maximum Jan. 27, 1915, mag. 7.4
Observations by Am Assn. of Var Star Observers
(x = obs by C.B.L.)



103769 R URSAE MAJORIS for 1915 C.B. Lindsley
Maximum Mar. 1, mag. 7.1; minimum Sept. 4, mag. 12.3.
Observations by Amer. Assn. of Var. Star Observers. (x=obs. by C.B.L.)




JAN
FEB.
MAR. Max. 1, Mar. 15, (9.4)
APR.
MAY Max. May 15, (9.4)
JUNE - Max. 3, Jun. 28, (8.7)
JULY
AUG. Max. 4, Aug. 26 (8.2)
SEPT.
OCT. Max. 5, Oct. 23 (8.3)
NOV.
DEC. Max. 6, Dec. 17, (9.5)
LIGHT CURVE for 1915 of 213843 SS CYGNI
Chas. B. Lindsley
Observations by American Association of Variable Star Observers.

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, Dec.-Jan., 1915-16.

The bad weather that seems to have prevailed generally over the United States during the past month is reflected in the small report we publish this month. In addition to this, the social demands of the holiday season have prevented many from observing, and the result is the smallest monthly list for three years.

There have been many inquiries of late concerning the work of the Association, and the prospects are bright for a largely augmented membership during the coming year.

VARIABLE STAR OBSERVATIONS Dec.-Jan., 1915-16.

001726
T Androm.

Mo.	Day	Est	Obs.
12	2	9.4	V
	2	9.7	Ly
	3	9.7	Bu
	5	9.6	O
	10	9.9	Ly
	11	10.3	Nt
	31	11.3	Nt

001755
T Cassiop.

Mo.	Day	Est	Obs.
12	3	9.0	Bu
	4	9.2	S
	22	8.7	E
	30	8.8	S
	31	8.8	Nt

001838
R Androm.

Mo.	Day	Est	Obs.
12	26	11.3	Hu

001909
S Ceti

Mo.	Day	Est	Obs.
12	3	8.5	Cr
	3	8.5	O
	3	8.4	Bu
	4	8.3	Ma
	7	8.5	O
	9	8.3	Hu
	30	9.0	S

003179
Y Cephei

Mo.	Day	Est	Obs.
12	3	9.8	Bu

004047
U Cassiop.

Mo.	Day	Est	Obs.
11	17	8.7	L
12	3	8.9	B
	11	10.5	Nt
	31	11.6	Nt

004435
V Androm.

Mo.	Day	Est	Obs.
12	3	9.7	Bu
	5	9.5	O
	9	9.2	Hu
	12	9.4	Nt

004533
RR Androm.

Mo.	Day	Est	Obs.
12	9	11.9	Hu

004746
RV Cassiop.

Mo.	Day	Est	Obs.
11	17	10.1	L

011208
S Piscium

Mo.	Day	Est	Obs.
12	5	9.8	O
	14	9.5	Bu
	31	9.9	O

012502
R Piscium

Mo.	Day	Est.	Obs.
12	3	9.2	Bu
	4	9.2	S
	5	9.1	O
	31	10.0	O

015254
U Persei

Mo.	Day	Est.	Obs.
12	2	8.5	V
	3	8.5	Bu
	7	8.5	O
	10	8.6	Ly

021403
***o* Ceti**

Mo.	Day	Est.	Obs.
11	6	6.5	L
12	30	3.7	Ma
	1	3.6	E
	1	3.7	Cr
	2	4.0	Ly
	3	4.0	O
	3	3.6	Bu
	3	3.6	Ma
	3	3.7	Cr
	4	3.4	Cr
	4	3.8	Nt
	5	3.4	E
	5	3.8	O
	6	3.6	Mu
	6	3.3	L
	7	3.6	O
	7	3.3	E
	7	3.8	Nt
	7	3.4	Mu
	9	3.3	Mu
	9	2.9	Hu
	10	3.4	Ly
	10	3.6	O
	11	3.4	O
	11	3.2	L
	11	3.7	Nt
	13	3.2	E
	19	2.8	Bu
	19	3.1	E
	21	3.2	O
	22	3.0	G
	22	3.0	Ma
	22	3.0	E
	22	2.4	M
	22	3.1	Mu
	23	3.2	G
	24	3.0	Mu
	25	3.5	G
	25	3.1	Mu
	26	3.0	Nt
	26	3.2	Pi
	26	3.1	Mu
	27	2.9	E
	27	3.1	Mu
	29	3.2	Mu
	30	3.5	Mu

***o* Ceti**

Mo.	Day	Est.	Obs.
12	30	3.1	Nt
	30	3.5	G
	30	3.2	Cr
	30	3.2	O
	31	3.2	O
	31	3.1	Cr
	31	3.4	Mu
	1	3.6	G
	6	3.2	O
	7	3.3	O
	9	3.3	O

021658
S Persei

Mo.	Day	Est.	Obs.
12	2	8.8	Ly
	3	8.5	Bu

022000
R Ceti

Mo.	Day	Est.	Obs.
12	31	7.9	O
1	7	7.9	O

022813
U Ceti

Mo.	Day	Est.	Obs.
11	30	9.0	Ma
12	9	9.0	Ma
	26	10.1	Pi
	31	10.3	Nt

023133
R Triang.

Mo.	Day	Est.	Obs.
12	11	9.7	Y

024356
W Persei

Mo.	Day	Est.	Obs.
11	11	10.2	L
12	11	10.3	Hu
	26	10.4	Pi

030514
U Arietis

Mo.	Day	Est.	Obs.
12	31	13.5	B

032043
Y Persei

Mo.	Day	Est.	Obs.
12	3	10.0	Bn
	7	9.9	Ly
	11	10.6	Hu

032335
R Persei

Mo.	Day	Est.	Obs.
12	3	10.0	Bu

033362
U Camelop.

Mo.	Day	Est.	Obs.
11	30	8.5	Ma
12	26	8.4	Pi

035915
V Eridani

Mo.	Day	Est.	Obs.
11	26	8.1	Ho

042036
T Camelop.

Mo.	Day	Est.	Obs.
12	11	13.5±	Y

042209
R Tauri

Mo.	Day	Est.	Obs.
12	1	13.4	B
	11	12.0	Hu

042215
W Tauri

Mo.	Day	Est.	Obs.
12	1	11.9	B
	9	11.4	Hu
	11	11.0	O
	22	10.7	M
	30	10.6	O
	31	9.5	B
1	6	10.1	O
	9	9.8	O

042309
S Tauri

Mo.	Day	Est.	Obs.
12	11	11.6	Hu

043208
RX Tauri

Mo.	Day	Est.	Obs.
12	1	8.7	B
	3	9.0	O
	11	9.3	Hu
	11	9.0	O
	24	9.0	B
	30	9.0	O
1	6	9.1	O

043274
X Camelop.

Mo.	Day	Est.	Obs.
11	6	8.5	L
	30	9.0	B
12	3	9.3	O
	5	9.0	O
	7	9.9	O
	7	9.8	Ly
	10	10.3	O
	11	10.8	L
	26	12.0	Pi
	31	12.3	Nt

044617
V Tauri

Mo.	Day	Est.	Obs.
12	1	10.3	B
	11	10.3	O
	14	9.6	Bu
	24	9.4	B
	30	10.1	O
	31	9.6	Nt

045514
R Leporis

Mo.	Day	Est.	Obs.
11	17	7.1	L
	26	7.1	Ho
12	10	7.4	Bu
	12	7.4	Ho

050003
V Orionis

Mo.	Day	Est.	Obs.
12	15	10.7	B

050022
T Leporis

Mo.	Day	Est.	Obs.
11	26	8.8	Ho
12	10	8.8	Bu
	12	8.3	Ho
	26	8.5	M

050953
R Aurigae

Mo.	Day	Est.	Obs.
11	28	13.0	B
12	27	12.8	B

052034
S Aurigae

Mo.	Day	Est.	Obs.
11	15	9.8	L
	30	8.9	B
12	11	9.8	L
	21	8.7	B
	26	9.2	Pi

052405
S Orionis

Mo.	Day	Est.	Obs.
11	26	7.9	Ho
12	3	8.8	Bu
	12	8.1	Ho
	15	8.4	B
	16	8.5	B
	22	8.4	M
	26	8.7	M

053005
T Orionis

Mo.	Day	Est.	Obs.
11	17	9.8	L
	26	9.8	Ho
12	3	10.0	Bu
	7	9.5	Nt
	10	9.4	B
	12	9.4	Ho
	22	9.3	M
	26	9.4	Pi
	27	9.5	E
	31	9.6	Nt

054319
SU Tauri

Mo.	Day	Est.	Obs.
1	7.5	9.5	O
	9.5	9.7	O

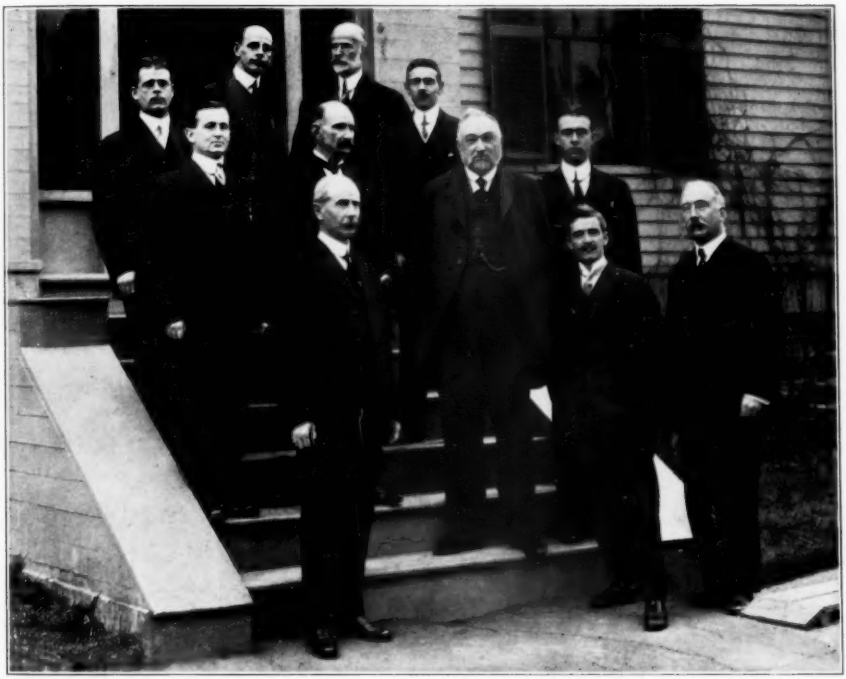
054920
U Orionis

Mo.	Day	Est.	Obs.
12	11	11.0	Hu
	11	12.2	Y
	26	11.6	Pi

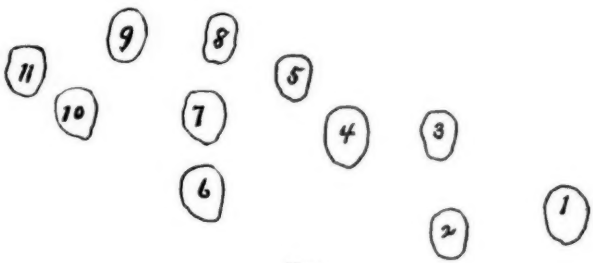
054974
V Camelop.

Mo.	Day	Est.	Obs.
12	3	10.5	O
	5	9.7	O
	10	9.5	O
	11	9.1	Y
	20	8.6	B

PLATE IV



MEETING OF THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS AT THE HARVARD COLLEGE OBSERVATORY, NOV. 21, 1915



KEY

1. J. L. Steuart	4. Prof. E. C. Pickering	8. Prof. S. I. Bailey
2. L. Campbell	5. W. T. Olcott	9. D. B. Pickering
3. G. F. Nolte	6. Rev. T. C. H. Bouton	10. F. H. Spinney
	7. C. Y. McAteer	11. A. B. Burbeck

VARIABLE STAR OBSERVATIONS Dec.-Jan., 1915-16—Continued.

V Camelop.

Mo.	Day	Est.	Obs.
12	21	8.5	B
	26	8.3	Pi
	30	9.0	O
1	6	9.0	O
	9	9.0	O

055353
Z Aurigae

12	26	10.0	Pi

060224
S Leporis

11	26	6.3	Ho
12	12	6.2	Ho

060450
X Aurigae

11	1	10.2	L
12	3	8.6	Bu
	26	8.6	Pi

060547
SS Aurigae

12	1.6	13.6	B

061647
V Aurigae

12	19	9.2	Bu

061702
V Monoc.

11	26	9.0	Ho
12	12	7.3	Ho

063558
S Lyncis

12	5	9.9	O
	7	9.6	Bu
	11	9.9	Y
	11	9.6	O
	20	9.5	B
	30	9.8	O
1	6	9.8	O
	9	9.4	O

065111
Y Monoc.

12	7	10.4	Bu

065208
X Monoc.

11	17	10.2	L
	26	7.5	Ho
12	7	7.6	Bu
	12	8.0	Ho

065358
R Lyncis

12	11	9.7	Y
	27	8.9	B
1	9	8.9	O

070122
R Gemin.

Mo.	Day	Est.	Obs.
12	31	9.1	Nt

070122 a
TW Gemin.

12	26	8.4	M
	31	7.9	Nt

070122 b
Z Gemin.

12	31	12.3	Nt

070310
R Can. Min.

11	17	10.2	L

072708
S Can. Min.

11	17	8.6	L
12	7	7.9	Ly
	26	7.3	M

073508
U Can. Min.

11	17	9.7	L

074323
T Gemin.

12	26	9.7	M

081112
R Cancri

11	17	11.0	L

082405
RT Hydrae

11	17	8.9	L
12	12	8.5	Ho

094211
R Leonis

11	17	5.8	L
12	14	6.6	M
	27	6.5	E

094622
Y Hydrae

12	12	6.5	Ho

103212
U Hydrae

11	17	5.0	L

103769
R Urs. Maj.

12	2	7.7	Ly
	4	7.5	S
	7	7.8	Bu
	10	7.6	Ly
	14	7.7	M
	29	7.0	M

104620
V Hydrae

Mo.	Day	Est.	Obs.
11	17	6.4	L
	26	6.6	Ho
12	12	6.7	Ho

122904
Y Virginis

12	12	11.4	Ho

123160
T Urs. Maj.

12	7	10.0	Bu
	7	9.8	Ly
	12	10.0	Ly
	14	10.5	M
	27	11.0	E

123307
R Virginis

11	17	10.6	L

123459
RS Urs. Maj.

12	14	9.3	M

123961
S Urs. Maj.

12	4	8.8	S
	7	8.2	Bu
	7	8.5	Ly
	14	8.7	M
	22	8.5	E
	27	8.4	E
	30	8.4	S

134440
R Can. Ven.

12	14	7.8	M

141567
U Urs. Min.

12	4	8.2	S
	7	8.3	Bu
	7	7.9	Ly
	20	7.7	B

141954
S Bootis

12	12	11.3	Nt

142539
V Bootis

11	11	7.4	L

142584
R Camelop.

11	11	10.3	L
12	11	11.8	L
	12	11.4	Ly
	31	12.5	B

143227
R Bootis

11	11	6.7	L

153378
S Urs. Min.

Mo.	Day	Est.	Obs.
11	6	11.7	L
12	7	12.0	Ly
	12	12.0	Ly

154428
R Cor. Bor.

10	22.2	6.1	L
11	1.2	6.0	L
	11.2	6.3	L
	17.2	6.5	L
	23.2	6.6	L
12	30.9	6.3	Nt

155847
X Herculis

12	12	6.8	Nt
	26	6.5	Nt

162807
SS Herculis

11	11	9.9	L

163172
R Urs. Min.

11	28	10.1	R
12	2	9.9	Ly
	20	9.8	Hr
	27	10.0	E

163266
R Draconis

12	1	11.7	Cr
	3	11.8	Cr
	4	11.7	Cr
	7	11.9	Ly
	31	11.8	B

164055
S Draconis

11	28	8.6	R

171723
RS Herculis

11	28	9.9	R

175458
T Draconis

12	20	9.6	Hr

181136
W Lyrae

12	22	9.9	M

183308
X Ophiuchi

11	11	7.0	L
	28	8.8	R

184205
R Scuti

10	22.2	6.1	L
11	11.2	5.3	L
	17.2	5.2	L
	23.2	4.9	L

R Scuti

Mo.	Day	Est.	Obs.
11	28.6	5.0	R
	29.6	5.5	R
12	4.5	5.2	Ma
	7.5	5.0	Ly
	11.5	5.7	Nt

184243
RW Lyrae

12	27	12.6	E

185243
R Lyrae

11	28.6	4.4	R

190108
R Aquilae

11	11	7.5	L
	23	8.3	L
	28	8.6	R
12	16	9.0	B

190926
X Lyrae

11	28	9.0	R
12	22	8.5	M

191019
R Sagittarii

11	28	7.6	R

193449
R Cygni

12	4	12.6	Hu
	15	11.2	B

193732
TT Cygni

11	6	7.9	L
	28	8.5	R
12	4	8.6	Ma
	4	8.0	Hu
	15	7.7	B
	21	8.0	M

194048
RT Cygni

11	28	8.4	R
12	2	9.0	Ly
	3	9.1	O
	4	8.7	S
	4	8.6	Hu
	4	9.0	Ma
	5	9.2	O
	10	9.6	Bu
	12	9.4	Ly
	15	9.0	B
	21	9.3	M

VARIABLE STAR OBSERVATIONS Dec.-Jan., 1915-16—Continued.

194348
TU Cygni

Mo.	Day	Est.	Obs.
11	28	9.1	R
12	3	10.2	O
	4	8.3	Hu
	7	10.4	Ly
	10	9.8	Bu
	22	10.5	M

194632
χ Cygni

Mo.	Day	Est.	Obs.
11	12	10.4	L
	23	10.2	L
	28	9.9	R
12	3	9.8	O
	4	8.8	Hu
	5	9.8	O
	7	9.6	Ly
	10	9.6	Bu
	11	9.0	O
	12	9.4	Ly
	20	7.3	B
	21	7.4	M
	27	6.7	E

195116
S Sagittae

Mo.	Day	Est.	Obs.
11	28.6	5.6	R
	29.6	5.9	R
12	4.5	5.9	Ma
	5.4	5.4	O
	6.6	5.8	Mu
	7.4	5.7	O
	9.6	5.9	Mu
	11.5	5.4	O

195849
Z Cygni

Mo.	Day	Est.	Obs.
12	1	9.3	V
	7	9.2	Ly
	10	9.0	Bu
	15	8.4	B
	21	8.6	M

200357
S Cygni

Mo.	Day	Est.	Obs.
12	31	9.5	B

200647
SV Cygni

Mo.	Day	Est.	Obs.
11	6	9.4	L
	28	9.2	R
12	4	8.9	Ma
	4	8.2	Hu
	12	8.6	Ly
	15	9.0	B
	21	8.6	M
	31	8.9	Cr

200715 a
S Aquilae

Mo.	Day	Est.	Obs.
11	28	10.2	R
12	10	9.5	Bu
	16	9.5	B

200715 b
RW Aquilae

Mo.	Day	Est.	Obs.
11	28	9.2	R
	29	9.6	R
12	10	9.0	Bu
	16	9.2	B

200812
RU Aquilae

Mo.	Day	Est.	Obs.
12	16	11.5	B

200916
R Sagittae

Mo.	Day	Est.	Obs.
11	28	8.5	R
12	16	9.1	B

200938
RS Cygni

Mo.	Day	Est.	Obs.
11	6	7.3	L
	23	7.2	L
	28	7.5	R
12	4	7.9	Ma
	7	7.5	Ly
	10	7.2	Bu
	21	8.3	M

201521
RT Capric.

Mo.	Day	Est.	Obs.
11	11	6.9	L
	23	6.6	L
	29	7.8	R

201647
U Cygni

Mo.	Day	Est.	Obs.
11	6	9.3	L
	28	7.0	R
12	4	7.5	Cr
	5	7.3	O
	7	7.4	Ly
	9	7.8	Mu
	12	7.2	Ly
	21	7.2	M
	24	7.7	Mu
	27	7.4	Cr
	27	7.0	Mu
	27	6.8	G
	29	6.8	Mu
	30	7.4	Cr
	31	7.2	Cr

202539
RW Cygni

Mo.	Day	Est.	Obs.
11	28	8.7	R
12	4	9.1	Ma
	21	9.0	M

202646
RZ Cygni

Mo.	Day	Est.	Obs.
12	11	9.3	L

202954
ST Cygni

Mo.	Day	Est.	Obs.
12	4	11.5	Hu

202946
SZ Cygni

Mo.	Day	Est.	Obs.
11	28	10.5	R
	29	10.6	R
12	21	9.2	M

203847
V Cygni

Mo.	Day	Est.	Obs.
12	16	8.5	B
	21	9.5	M

204016
T Delphini

Mo.	Day	Est.	Obs.
11	28	10.2	R

204378
V Delphini

Mo.	Day	Est.	Obs.
12	3	10.7	O

205923
R Vulpec.

Mo.	Day	Est.	Obs.
11	28	9.0	R
12	4	8.3	Hu
	11	8.3	Hu
	22	8.8	M

210116
RS Capric.

Mo.	Day	Est.	Obs.
11	28	8.2	R

210868
T Cephei

Mo.	Day	Est.	Obs.
11	1	6.4	L
	15	6.3	L
12	7	6.3	Ly
	12	6.1	Lp
	15	6.3	Nt
	15	6.3	Bu
	27	7.0	Nt

213244
W Cygni

Mo.	Day	Est.	Obs.
10	22	5.7	L
11	6	5.8	L
	23	6.3	L
	29	6.3	R
12	11	6.3	L

213753
RU Cygni

Mo.	Day	Est.	Obs.
12	10	7.8	Ly
	21	8.4	M

213843
SS Cygni

Mo.	Day	Est.	Obs.
11	6.4	11.8	L
	11.3	11.8	L
	15.3	11.8	L
	23.3	11.8	L
	30.6	11.7	B
12	1.6	11.7	B
	4.6	11.8	Hu
	5.6	11.7	E
	7.6	12.1	Nt
	10.6	11.8	B
	11.3	11.8	L
	11.5	12.0	Hu
	11.6	11.9	Nt

SS Cygni

Mo.	Day	Est.	Obs.
12	12.5	11.9	Nt
	14.6	10.7	E
	15.5	8.7	Bu
	15.6	8.8	B
	15.6	8.6	M
	15.6	8.2	Nt
	16.5	8.6	B
	16.5	8.3	Bu
	19.5	8.7	B
	19.5	8.3	O
	20.5	8.6	B
	20.6	8.8	Hr
	21.5	8.7	B
	21.5	8.3	O
	21.5	8.4	M
	22.5	8.8	B
	22.5	8.5	Ma
	22.5	8.3	M
	22.6	8.5	E
	23.5	8.3	M
	24.5	8.9	B
	26.5	9.4	Bu
	26.5	9.0	Hu
	26.6	9.3	B
	27.5	9.5	B
	27.5	9.3	E
	27.6	9.1	Cr
	27.6	9.5	Mu
	27	9.5	G
	28.6	9.7	B
	29.6	9.4	Mu
	30.4	10.4	O
	31.5	10.5	B
	31.5	10.9	Nt
	31.6	11.1	Cr

213937
RV Cygni

Mo.	Day	Est.	Obs.
11	11	7.8	L
	29	8.6	R
	30	8.5	Ma
12	4	8.6	Ma
	4	8.0	Hu
	15	7.9	B
	21	8.2	M

215934
RT Pegasi

Mo.	Day	Est.	Obs.
12	15	9.2	Bu

220613
Y Pegasi

Mo.	Day	Est.	Obs.
12	16	9.5	B

220714
RS Pegasi

Mo.	Day	Est.	Obs.
12	2	9.0	V
	16	8.9	B
1	7	9.3	O

222439
S Lacertae

Mo.	Day	Est.	Obs.
12	31	12.6	B

225120
S Aquarii

Mo.	Day	Est.	Obs.
11	30	8.4	Ma
12	4	8.2	Ma
	18	12.9	B
	26	9.3	Hu

225914
RW Pegasi

Mo.	Day	Est.	Obs.
12	9	10.3	Mu
	21	9.4	M
	24	10.1	Mu
	27	9.9	Mu
	27	9.9	G
	29	9.8	Mu

230110
R Pegasi

Mo.	Day	Est.	Obs.
12	3	7.5	O
	4	7.5	Ma
	5	7.4	O
	10	7.5	O
	12	7.5	Ly
	15	7.3	Bu
	21	7.7	O
	21	7.3	M
	22	7.3	Ma
	29	7.4	Mu
	30	7.0	Nt
	30	7.7	O
1	6	8.1	O

230759
V Cassiop.

Mo.	Day	Est.	Obs.
12	11	9.6	O
	27	10.3	E
	31	10.7	O

233335
ST Androm.

Mo.	Day	Est.	Obs.
12	4	10.0	Hu
	10	10.4	Ly
	22	10.7	E
	30	10.6	S
1	6	10.7	O

233815
R Aquarii

Mo.	Day	Est.	Obs.
12	4	9.5	Ma
	26	9.2	Hu

235350
R Cassiop.

Mo.	Day	Est.	Obs.
12	15	8.0	Bu
	22	8.1	E
	30	7.6	Nt

235525
Z Pegasi

Mo.	Day	Est.	Obs.
12	2	9.2	V
	3	9.5	O
	27	8.8	E
	30	8.4	O
1	7	8.5	O

235939
SV Androm.

Mo.	Day	Est.	Obs.
12	4	11.0	Hu
	27	12.5	E

No. of observations 484; No. of stars observed 134; No. of observers 20.

We welcome as a member of the Association this month Mr. Nicholas D. Cheronis, "Ch", of the Lane Technical High School, Chicago, Ill. Mr. Hatcher's abbreviation for the reports will be "Ht" instead of "Hr", the abbreviation incorrectly assigned to him in the last report. "Hr" designates the observations contributed by professor Harrell, of Millsaps College, Jackson, Miss.

The December 6 issue of *The Independent* contained a brief account of the Association and the work we are engaged in, and brought us a number of requests for information concerning our organization.

Mr. Hunter calls attention to an error on the chart of the Variable 004533 RR Andromedae. The 11.6 magnitude comparison star lies between the 9.2 and the star now designated 11.6. It is a source of gratification that we are gradually eliminating the small errors in the charts that are bound to creep into such an extensive work

Mr. Lindsley deserves credit for the light curves derived from our observations that he continues to publish in POPULAR ASTRONOMY.

The historic variable *021403 o* Ceti has been exceedingly well observed during the past month, and although the calculated date of maximum is January 8, the observed maximum seems to have occurred during the third week in December. The magnitude at maximum was approximately 3.0

A long maximum of the variable 213843 SS Cygni was well observed during the latter part of December. Now that this variable will soon be too close to the sun for observation, our attention should be especially directed to the observation of the irregular variables 054319 SU Tauri, 060547 SS Aurigae, and 074922 U Geminorum. It is a good plan to observe these variables first each evening, then if clouds come up later you have secured the more important data.

The following calculated dates of maximum may be of interest. They are cited from the "Companion to the Observatory."

Jan.	8	015354	U Persei	Feb.	3	194632	χ Cygni
	8	*021403 o*	Ceti		4	181136	W Lyrae
	9	195849	Z Cygni		6	*022000*	R Ceti
	12	*132606*	S Virginis		15	134440	R Can. Ven.
	13	*001909*	S Ceti		22	123307	R Virginis
	20	084803	S Hydrae		24	213678	S Cephei
	20	093934	R Leo. Min.				

The secretary will be glad to furnish observers at any time special charts they may require. The aim should be in every case to extend the observing list to cover as many variables as possible.

As the Secretary expects to be away from home in February, will members please endeavor to send their lists to him by the first day of the month.

The following members contributed to this report:—Messrs. Bouton, Burbeck, Crane, Eaton, Gray, Harrell, Hoge, Hunter, Lacchini, Lindsley, Mach, McAteer, Mundt, Nolte, Olcott, Pickering, Richter, Vrooman, Miss Swartz and MissYoung.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Jan. 10, 1916.

α Orionis.—In the November 1915 number of the *Observatory* is a brief article by an English Astronomer on α Orionis. He states that about the middle of October 1915 α Orionis was *fainter* than α Tauri (Aldebaran), and was nearly midway between α Tauri and γ Orionis. I cannot agree with him in regard to this. I have seen α Orionis *equal* to α Tauri, but never fainter. α Orionis early in

December was less than one tenth of a magnitude brighter than α Tauri, but since then it has brightened *very slightly*. I would like to have you ask the question of variable star observers in the next number of POPULAR ASTRONOMY if any of them have even seen this variable (*irregular*) *fainter* than α Tauri, and when.

F. E. SEAGRAVE.

Boston, December 24, 1915.

COMET AND ASTEROID NOTES.

Comet 1915 *e* (Taylor), Elliptic Elements.—In the *Lick Observatory Bulletin* No. 276 are given elliptic elements of comet 1915 *e*, computed by Ferd. J. Neubauer and H. M. Jeffers of the Berkeley Astronomical Department, University of California. The elements are based upon observations on December 7, 13 and 18. There is considerable discrepancy between the thirteen observations which cover the above interval, so that the elements are somewhat uncertain.

ELEMENTS.

T = 1916, January 27.906 Gr. M. T.
ω = 342° 54′
Ω = 114 52 } 1916.0
i = 14 30
log q = 0.18170
log a = 0.48282

μ = 669″.544
Period = 5 .299 years

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1916	True α	True δ	log Δ	Br.
	h m s	° ′		
Jan. 2.5	5 8 12	+ 8 10.3	9.7798	1.14
4.5	7 39	7 59.6		
6.5	7 14	9 50.2		
8.5	6 59	10 41.5	9.7849	1.13
10.5	6 54	11 33.3		
12.5	7 01	12 25.5		
14.5	7 18	13 17.8		
16.5	7 47	14 10.2	9.7984	1.07
18.5	8 28	15 02.4		
20.5	9 22	15 54.2		
22.5	10 27	16 45.6		
24.5	11 44	17 36.4	9.8182	0.98
26.5	13 13	18 26.4		
28.5	14 55	19 15.5		
30.5	16 49	20 03.6		
Feb. 1.5	5 18 55	+20 50.7	9.8428	0.88

An observation at Goodsell Observatory on January 6 indicates a correction of −14ˢ.4, −5′.7 to the ephemeris at that time. The observed position was as follows:

Gr. M. T.	α	δ	Observer
	h m s	° ′ ″	
Jan. 6.5833	5 06 59.08	+9 45 20.2	Wilson

The course of the comet during February will be between the horns of Taurus into the southeastern part of Auriga. Unfortunately no ephemeris is at hand for this month.

Comet 1915 *a* (Mellish).—This was easily visible in our 5-inch finder on January 7, the observed position being

Gr. M. T.	α	δ	Observer
	h m s	° ′ ″	
Jan. 7	3 24 42.15	+11 40 05.1	Wilson

No ephemeris for February is at hand.

COMMUNICATIONS.

Comet 1915 *e* (Taylor).—I wish to report that I observed Comet 1915 *e* (Taylor) on 1916 January 5^d 8^h.

At this observation I used a 4-inch telescope and while I found the comet from the ephemeris given in POPULAR ASTRONOMY after sweeping for about twenty minutes, yet I must say it was extremely faint. I doubt very much whether it can be seen at all with an aperture less than 4 inches.

WILLIAM H. CASSELL.

Wytheville, Virginia.
1916, January 6.

Internal Planetary Forces.—The force which occasions the sun-spots and that which makes its presence known upon our earth in the form of earthquakes and volcanic outbursts are so much alike, when due allowance is made for the physical difference of the bodies upon which the forces act, that one can with much certainty look upon them as the same phenomenon. Both forces act from within, both are periodic and both show a likeness in their periods as well as in their modus agendi.

Both forces act from within. The seismograph receives its vibrations from the body of the earth and leaves no doubt but that in regard to our planet the disturbance recorded is caused by an internal force. The volcano confirms us in this. Of all known forces acting upon the sun from without, the planets must exert the greatest force; but even these can, by their positions, be proven to have no connection with the topographical disturbances of that body. Hence, in this case too must we look for a force within.

Both forces are periodic. The sun-spot period of eleven years is well known. The earth's period of disturbance is about one hundred years, the great length of the period being due probably to the great surface-rigidity, which prevents the force from spending itself more quickly. During these periods, both upon the sun and upon the earth, we find a short period of quiescence followed by an outburst of longer duration, the two periods being constantly proportional to each other. Upon the sun the quiescent period lasts at an average for two years and upon the earth for about seventeen.

Both forces show a likeness in their periods as well as in their modus agendi. Taking D for the density of the celestial bodies, Pr for their period of axial-rotation and Pd for their entire period of disturbance, we find that, in the case of both earth and sun, the greater the quotient of $\frac{D}{Pr}$, the greater is Pd. If D be represented as one in the case of the earth, and Pr and Pd in hours, we find that their relationship upon the sun and the earth can be represented respectively, thus:

	D/Pr	Corresponding Pd
$\frac{.25}{607}$	$= .0004$	90,000 hrs.
$\frac{1}{24}$	$= .04$	900,000 "

from which the following table can be developed:—

D/Pr		Pd	
.000,004	=	9,000	hrs.
.000,4	=	90,000	
.04	=	900,000	

If now this force be considered as acting within other planets, we can compute approximately as follows:—

Sun's	Pd	is	90,000	hours
Mercury's	"	"	90,000	"
Venus'	"	"	89,000	"
Earth's	"	"	900,000	"
Mars'	"	"	890,000	"
Jupiter's	"	"	890,000	"
Saturn's	"	"	880,000	"

Concerning the remaining planets we can say nothing in this matter, their elements not being sufficiently known.

Still another likeness can be found in comparing the effects of this force upon the sun and upon the earth. The quiescent period is to the whole period as two is to eleven. From this we can conclude the following periods:—

Sun	2	years	of	quiescence	and	9	years	of	activity
Mercury	2	"	"	"	"	9	"	"	"
Venus	2	"	"	"	"	8¼	"	"	"
Earth	17	"	"	"	"	83	"	"	"
Mars	18	"	"	"	"	83	"	"	"
Jupiter	1½	"	"	"	"	99½	"	"	"
Saturn	18¼	"	"	"	"	83	"	"	"

GEORGE F. KRONENBERGER.

GENERAL NOTES.

Dr. W. W. Campbell, president of the American Association for the Advancement of Science, delivered an illustrated address on "The evolution of the stars," on the evening of January 3, the occasion being a special meeting of the Association held in Washington, D. C., January 3 and 4 in honor of the Pan-American Congress.

The New Bedford Astronomical Society of New Bedford, Mass., has purchased a 5-inch portable telescope, which they hope to use with much advantage when the weather and skies are suitable.

Observations on Mars at the Lowell Observatory during the present opposition show that the canal development strikingly corroborates the theory of seasonal dependence on the melting of the polar cap. The northern canals are now very dark indicating increased activity with advancing spring, while the southern canals are faint in their autumnal decline. The season in the northern hemisphere of Mars is now late April.

Recent Observations of Saturn at the Lowell Observatory show a remarkable change in the color and brightness of the planet's ball which is now of a pinkish brown tint and strikingly darker than the rings. Comparisons of the stellar magnitude of the planet with Capella, Procyon and Mars also show that its brightness is less than the predicted value in the ephemeris.

Saturn's Rings.—The last number of the memoirs of the Lowell Observatory announces a discovery in connection with Saturn. The investigation, by Director Lowell, is concerned with the theoretic and observed positions of the recently discovered as well as the old divisions of the ring-system. All of these divisions are caused by the perturbing action of Mimas on the particles of the rings. In consequence of their not quite agreeing with the theoretic positions an investigation was entered into which has succeeded in throwing new light on the internal condition and distribution of the matter composing Saturn's ball. The observed positions of these divisions can seemingly only be reconciled by a greater internal oblateness than has hitherto been supposed which demands a greater speed in the kernel than the husk. Not the least interesting fact about this result is that measures on the rings should lead to a discovery about Saturn's internal constitution.

Notes from the Yerkes Observatory.—The sky was less clear at night during 1915 than on the average. This was due to the more even distribution of the precipitation, of which the total was only slightly larger than the average. Rain fell on more days during the summer than usual.

The figures are, for observation with the 40-inch telescope at night, in 1915, 1602 hours; mean for the decade 1903-12, 1682 hours. The record is considerably poorer than for 1913, when there were 1822 hours; but much better than for 1914, when there was a very low record of 1480 hours.

The total precipitation recorded in 1915 amounted to 824 mm, as compared with the 10-year normal of 802 mm.

The Astronomical Club at the Observatory was favored with a most interesting lecture by **Dr. C. E. Kenneth Mees,** head of the Research Laboratory of the Eastman Kodak Company, on November 21. His topic covered a discussion of the gradation of plates and papers, of scale, and of resolvability of photographic plates.

Mr. Clifford C. Crump, who recently completed his work for the Doctor's degree at the University of Michigan, has been temporarily at the Observatory since the middle of October, as computer in spectroscopy, and has been engaged in measuring spectrograms. He begins his teaching at Carleton College on February 1, for the second semester.

Miss Harriet McW. Parson, who has a traveling fellowship from Vassar College, spent the autumn quarter at the Observatory. She will be occupied at the University of Chicago during the winter quarter, and will later return to the Observatory to complete her work for the Master's degree.

Mr. Julius Lemkowitz (B. S., University of Mississippi, 1915) has been engaged as temporary computer in spectroscopy since the end of the summer.

Mr. John E. Mellish has removed from Cottage Grove, Wisconsin, to Williams Bay, and is regularly sweeping the sky for comets, using various telescopes of the Observatory.

The Alvan Clark & Sons Corporation will continue its work under the direction of C. A. Robert Lundin, who for the past twenty years has been associated in the work of constructing the large objectives sent out by this firm.

The Spectrum of the Companion of Sirius.—Recent photographs of the companion to Sirius taken at the Mount Wilson Observatory seem to indicate that the line spectrum is identical with that of Sirius, but that there is a slight tendency for the continuous spectrum of the companion to fade off more rapidly in the violet region.

A Testimonial Dinner to Dr. John A. Brashear.—On November 24 Dr. John A. Brashear of Pittsburgh completed his 75th year. His many friends took advantage of the occasion to show him in what respect and affection he is held. A testimonial dinner was given in the largest dining hall in Pittsburgh and this was filled to the full by friends from far and near; indeed so great was the demand for tickets that a hall twice the size would not have sufficed for all who wished to be present. During the dinner a number of poems that had been written for the occasion were read, and a selection was made from the many telegrams and messages of appreciation that were received, including one from President Wilson, one from Governor Brumbaugh and others from distinguished friends in this country and abroad. The dinner was followed by a pageant representing some of the scenes in Brashear's life; his early struggles to become a maker of lenses while still laboring as a mill hand; the breaking of his first mirror after he and his devoted wife had worked upon it for several years; and his final triumph and entrance into the "world of light." This was followed by a procession of representatives of the many universities, societies and clubs with which Dr. Brashear has been affiliated. The rear of this procession was brought up by 75 members of the Phoebe Brashear Club. This organization is named for Mrs. Brashear, who died in 1910. Its membership is made up of teachers in the public schools of Pittsburgh, originally those who had received the benefits of the Educational Fund Commission, of which Dr. Brashear is the Chairman. Each of the members was clad in white and carried an American Beauty rose, which she presented to Dr. Brashear as the procession passed him, "A rose for every year." The celebration was brought to a close by an announcement on the part of the committee in charge, to the effect that a fund of $50,000 had been raised to establish a "John Alfred Brashear Lectureship" in Pittsburgh. The object is to attempt to perpetuate the valuable popular lectures on Astronomy and similar subjects that Dr. Brashear has been giving for many years, and always without financial recompense. Dr. Brashear himself is to hold this lectureship during his remaining years.

A Trans-Neptunian Planet.—Mr. Percival Lowell has recently published an important memoir on "A Trans-Neptunian Planet" in *Memoirs of the Lowell Observatory*, Vol. I, No. 1. He takes up an analytical study of the residuals between the observed places of Uranus from 1709 to 1910 and the theoretical positions calculated according to Leverrier's theory of Uranus of 1873 and according to Gaillot's later and more accurate theory. The residuals from Gaillot's theory are all under 2″.5, except that for the year 1752 which amounts to 4″.45, and the alternations of sign are such that one at first glance would not expect to find in them much evidence of the perturbative effect of an unknown planet. Mr. Lowell, however, by rigorous least square solutions finds that the sum of the squares of the residuals is reduced 71% on the hypothesis of an outside disturbing body in heliocentric longitude, July 0, 1914, about 84° or 263°. The two solutions give little choice between them. The first gives the smallest residuals, but the region of the ecliptic around and west of 84° is accessible to northern observatories and has been pretty thoroughly searched

for many years. The other region is too low for northern observers and therefore is a better hiding place for an undiscovered planet. The results indicate an eccentricity of about 0.2 and, as large inclinations are usually associated with high eccentricities, one might expect an inclination of the orbit to the ecliptic of possibly 10°, which would make the planet the more difficult to find. The solution indicates for the unknown body a mass between that of Neptune and that of the earth; a possible magnitude of 12 to 13, according to albedo; and a disk of more than 1″ in diameter. Mr. Lowell emphasizes the uncertainty of his results by saying: "Owing to the inexactitude of our data, then, we cannot regard our results with the complacency of completeness we should like. Just as Lagrange and Laplace believed they had proved the eternal stability of our system, and just as further study has shown this confidence to have been misplaced; so the fine definiteness of positioning of an unknown by the bold analysis of Leverrier or Adams appears in the light of subsequent research to be possible only under certain circumstances. Analytics thought to promise the precision of a rifle and finds it must rely upon the promiscuity of a shot gun after all, though the fault lies not more in the weapon than in the uncertain bases on which it rests. But to learn of the general solution and the limitations of a problem is really as instructive and important as if it permitted specifically of exact prediction."

What is the Matter with Astronomy?—The following is from an editorial by Mr. Leon Barritt, publisher of the *Evening Sky Map*, in the January number of that publication:

"I am deeply interested in astronomy. I have found it a pleasurable diversion from the activities of a busy life, and I think every one should become acquainted with the "friendly stars." The facts are, however, that the subject receives comparatively little attention. I have found that astronomy is not taught in a single Grammar School in the United States. A few High Schools give it consideration in connection with physical geography, and in the Colleges and Universities it is elective, and very few take it up. In my boyhood astronomy was a part of the curriculum in every educational institution in the country. What has brought about this great change? I believe it is largely due to the abstract manner in which the subject has been presented in textbooks, making the subject repellent to teachers as well as students, and in no small degree has it been brought about by parents who want their children educated along lines that would have more commercial value. Statistics show that fully seventy five per cent of the children who graduate from the Grammar School do not enter High School, so this large percentage of boys and girls go out into life without the slightest knowledge of the great solar system of which we are a part. They know nothing of the apparent rising and setting of the sun, the cause of the moon's phases, or any of the simplest facts regarding astronomy.

"From these facts I am convinced that *The Evening Sky Map* has a most worthy mission in its endeavor to awaken and develop an interest in one of the grandest of sciences. I have been occasionally urged to enlarge it so as to publish longer articles. This I believe would be a grave mistake and defeat the purpose of the publication—that is, to present, at a low price, a monthly ready reference of the heavens, that can be carried in the pocket or hand bag anywhere. To increase its size would necessarily increase the cost to the subscriber. I can see no advantage in it. The field for the magazine for the advanced student in astronomy and for the professional astronomer is now amply and splendidly supplied in this country by POPULAR ASTRONOMY, published at Northfield, Minnesota. I have no desire to invade its field."

Resumé of Sunspot Observations at Mount Holyoke College, 1915.

Month	No. of Obs.	Days without No groups	North of equator No. groups	North of equator Av. Lat.	South of equator No. groups	South of equator Av. Lat.	Av. No. at each Obs.	New groups
Jan.	13	3	5	+18.8°	1	−21.0°	1.46	6
Feb.	15	1	6	20.8	10	19.1	3.47	16
Mar.	23	0	8	21.9	7	19.4	3.26	10
Apr.	21	3	5	22.0	8	20.4	2.19	10
May	21	7	6	20.5	3	16.3	2.05	6
June	13	3	6	17.3	5	19.8	1.92	9
Sept.	7	0	3	17.0	1	16.0	2.43	4
Oct.	13	0	7	18.1	3	16.3	2.69	9
Nov.	66	0	8	24.5	6	19.0	2.75	13
Dec.	10	0	4	15.8	5	18.8	2.50	8
	152	17	58		49			91

Average number at each observation 2.51
Average latitude of spots north of equator +19.8
Average latitude of spots south of equator −19.1

The method of observation was the same as that followed in previous years. During the first half year the record was kept by Miss Anna D. Lewis, Ph. D., during the second half year by Miss Louise F. Jenkins.

ANNE SEWELL YOUNG.

Mount Holyoke College.

Publications of the Allegheny Observatory.—Three numbers 19, 20 and 21 of Volume III of the Publications of the Allegheny Observatory have just come to hand.

Number 19 contains tables for Parallax Factors in Right Ascension. These tables cover four pages and give the parallax factor parallel to the equator to two decimals with the horizontal argument $\odot$, the longitude of the sun, for every hour; and the vertical argument $\odot - \alpha$ for every ten minutes from $5^h\ 20^m$ to $7^h\ 0^m$, and for every five minutes from $7^h\ 0^m$ to $10^h\ 25^m$.

Number 20 gives a discussion by Professor Schlesinger of the results of spectrographic observations of λ Tauri, indicating the presence of a third body in the system. λ Tauri is a well-known eclipsing variable star with a period of about four days. The third component is more distant than the second, probably about 4.5 times as far away, and has a period of 34.60 days. The mass of the distant satellite is very closely equal to two fifths of that of the eclipsing satellite. Under the most probable assumptions, the masses of the three bodies are respectively 2.5, 1.0 and 0.4 times that of the sun. The mean distances of these bodies from the centroid of the bright body and its eclipsing satellite are 3,200,000 km, 8,000,000 km and 50,000,000 km.

Number 21 gives a discussion by Zaccheus Daniel of the orbit and spectrum of VV Orionis. This is one of the stars whose spectra show oscillations of the hydrogen and helium lines while the K line of calcium, which is narrow and sharp, remains practically stationary. The orbit comes out circular, with a radius of about 2,700,000 km, orbital velocity about 132 km and radial velocity of the system +20.77 km. There is some evidence of a slow oscillation, produced by the disturbance of a third body, with a period of 120 days, but this is not very certain.

The velocity of the syetem obtained from the K line comes out +16.7 km, which is in close agreement with the velocities obtained for the same line in the spectra of δ and ϵ Orionis, which are in the same region of the sky and which exhibit the same

phenomenon of sharp K lines, while the hydrogen and helium lines are broad. The simple mean of the K-line velocities from the three stars is + 16.8 km, which is very nearly the same as the motion of the sun away from that region of space. The hypothesis of a calcium cloud, stationary in space, between us and these stars, thus finds support. Whether the stars are in the cloud or not it is not possible to decide.

Dr. Coblentz' Measures of Stellar Radiation.—In the summer of 1914 Dr. W. W. Coblentz, of the U. S. Bureau of Standards, conducted some remarkable experiments in measuring the amount of radiation from various stars, by means of thermo-electric apparatus in connection with the 36-inch Crossley reflecting telescope at the Lick Observatory. The radiometer used was many times more sensitive than those previously used, and Dr. Coblentz was able to get measurable deflections of the galvanometer from stars as faint as 6.7 magnitude. He thinks, however, that much more sensitive apparatus must be constructed in order to study the radiation of fainter stars and the distribution of the energy of radiation in the spectrum. His discussion of the results is given in the *Lick Observatory Bulletin* No. 266.

From the measurements made on 105 stars Dr. Coblentz has drawn some very interesting conclusions. He finds that stars of the same brightness to the eye, but of different colors, have very different radiant energy. For example in the "Big Dipper" the yellow star α in the "pointers" is even fainter to the eye than the blue star ϵ in the "handle", but the total radiation emitted by the former is nearly double that of the latter. In general it was found that red stars emit from two to three times as much total radiation as blue stars of the same photometric magnitude.

By measurements of the radiations of stars and planets transmitted through an absorption cell of water it was found that, of the total radiation emitted, the blue stars have about twice as much radiation as the yellow stars and three times as much as the red stars, in the spectral region to which the eye is sensitive.

In the case of double stars with components of different color, the fainter component often emits the greater part of the total radiation.

In estimating the amount of stellar radiation falling upon the earth Dr. Coblentz finds the quantity "so small that it would require the radiations from Polaris falling upon one square centimeter to be absorbed and conserved continuously for a million years in order to raise the temperature of one gram of water 1° centigrade. If the total radiation from all the stars falling upon one square centimeter were thus collected and conserved, it would require from one hundred to two hundred years to raise the temperature of one gram of water 1° C. In marked contrast with this, the solar rays which reach the earth's surface can produce the same effect in about one minute."

The sensitiveness of the apparatus used was such that, when combined with the three-foot mirror, it should have registered a deflection of 1 mm when directed upon a candle placed at a distance of 53 miles. The sensitiveness required for satisfactory study of the distribution of radiant energy in the spectrum of the stars is about 100 times as great, i. e. the apparatus must yield a measurable deflection equivalent to that from the rays of a candle removed to a distance of 500 miles. Dr. Coblentz thinks this increase of sensitivity is possible, by the use of a 7-foot reflector and by increasing the sensitiveness of the radiometer (thermo-couple and galvanometer) twenty times.

Professor Edwin B. Frost, director of the Yerkes Observatory, has kindly communicated the following tabular summary of Dr. Coblentz' results, arranged in the

order of the spectral class of the stars, which was used in presenting a discussion of the subject to the Yerkes Astronomical Club. It brings out very clearly the progression in total radiation with the order of spectral class B, A, F, G, K, M, N, and the accompanying color progression, from blue (Class B) to very red (Class N).

Summary, arranged according to Spectral Classes, of the Radiometric Measures on 110 Stars made by Dr. W. W. Coblentz with the Crossley Reflector at the Lick Observatory.

NOTE—In presenting to the Astronomical Club at the Yerkes Observatory the remarkable results obtained by Dr. W. W. Coblentz, of the Bureau of Standards, in his measurements with the thermopile of the total radiation of 110 stars, with the use of the Crossley reflector of the Lick Observatory during the summer of 1914, it seemed advantageous to collect the tabular data in a manner somewhat different from that given in Lick Bulletin No. 266 and in Bulletin No. 4, Vol. XI, of the Bureau of Standards. At my suggestion this was done by Mr. Julius Lemkowitz, computer in spectroscopy at the Yerkes Observatory. The galvanometric deflections obtained for the same star were averaged, and the results for the different stars were averaged by types and certain sub-types. For further advantage of comparison the deflections were also reduced to what they should be at magnitude 3.0. The name of the star, in the first column, is followed by its sub-class and magnitude, in the second and third columns; in the fourth column is given the galvanometric deflection, and in the fifth this deflection reduced to what it would be if the star's magnitude were 3.0. The means for each group are given below the group.

EDWIN B. FROST.

Stars of Class B

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
γ Cassiopeiae	Bp	2.25	0.31 cm	0.16 cm
δ Scorpii	B0	2.54	0.54	0.35
β Cephei	B1	3.32	0.28	0.38
β Scorpii	B1	2.90	0.33	0.30
ζ Persei	B1	2.91	0.39	0.36
γ Pegasi	B2	2.87	0.33	0.29
δ Ceti	B2	4.04	0.08	0.20
γ Orionis	B2	1.70	0.91	0.27
η Ursae Majoris	B3	1.91	0.64	0.23
ζ Draconis	B5	3.22	0.32	0.38
ι Aquilae	B5	4.28	0.05	0.16
δ Persei	B5	3.10	0.44	0.48
β Librae	B8	2.74	0.47	0.37
ζ Pegasi	B8	3.61	0.15	0.26
β Persei	B8	2.6	0.77	0.53
β Tauri	B8	1.78	0.92	0.30
β Orionis	B8p	0.34	2.50	0.22
17 stars	B4	2.71	0.56	0.31
Omitting B8	B 2.5	2.70	0.35	0.29
B8	B8	2.21	0.96	0.34

Stars of Class A

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
α Lyrae	A0	0.14	3.54 cm	0.25 cm
α Pegasi	A0	2.57	0.31	0.21
α Coronae Borealis	A0	2.31	0.51	0.27
ζ Aquilae	A0	3.02	0.28	0.28
α Andromedae	A0	2.15	0.41	0.19
β Ursae Majoris	A0	2.44	0.37	0.22
γ Ursae Majoris	A0	2.54	0.27	0.18
ε Ursae Majoris	A0p	1.68	0.85	0.25
ε Herculis	A0	3.92	0.14	0.32
δ Herculis	A0	3.16	0.33	0.36
θ Aquilae	A0	3.37	0.22	0.31
ε Aquarii	A0	3.83	0.10	0.21
η Ophiuchi	A0	2.63	0.30	0.21
γ Aquarii	A0	3.97	0.24	0.60
ν Tauri	A0	3.94	0.12	0.29
α Cygni	A2	1.33	1.47	0.43
ζ Sagittarii	A2	2.7	0.33	0.25
α Piscis Australis	A3	1.29	0.90	0.19
α Ophiuchi	A5	2.14	0.64	0.29
α Aquilae	A5	0.89	1.73	0.53
δ Capricorni	A5	2.98	0.28	0.28
θ^2 Tauri	A5	3.62	0.18	0.32
22 stars	A 1.2	2.57	0.62	0.29

Stars of Class F

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
δ Aquilae	F0	3.44	0.30 cm	0.45 cm
β Cassiopeiae	F5	2.42	0.34	0.20
α Persei	F5	1.90	1.38	0.50
γ Serpentis	F8	3.86	0.32	0.70
γ Cygni	F8p	2.32	0.47	0.25
α Ursae Minoris	F8	2.12	0.60	0.18
6 stars	F 5.7	2.68	0.57	0.38

Stars of Class G

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
η Pegasi	G0	3.10	0.34 cm	0.37 cm
β Draconis	G0	2.99	0.44	0.44
ζ Herculis	G0	3.00	0.39	0.39
β Capricorni	G0p	3.25	0.50	0.63
β Aquarii	G0	3.07	0.55	0.58
α Aquarii	G0	3.19	0 69	0.82
α Aurigae	G0	0.21	6.14	0.47
γ Persei	G0p	3.08	0.72	0.77
γ Tauri	G0	3.86	0.36	0.79
η Draconis	G5	2.89	0.65	0.59
μ Herculis	G5	3.48	0.41	0.67
11 stars	G 0.9	2.92	1.02	0.59

Stars of Class K

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
α Boötis	K0	0.24	8.57 cm	0.67 cm
ε Pegasi	K0	2.54	0.82	0.54
α Serpentis	K0	2.75	0.62	0.49
ε Cygni	K0	2.64	0.60	0.43
α Ursae Majoris	K0	1.95	1.19	0.74
β Ophiuchi	K0	2.94	0.40	0.39
δ Draconis	K0	3.24	0.54	0.67
ε Draconis	K0	3.99	0.16	0.40
α Cassiopeiae	K0	2.6	0.57	0.39
γ Andromedae, A	K0p	2.2	1.4	0.67
ε Boötis	K0	2.7	0.83	0.63
ε Ophiuchi	K0	3.34	0.43	0.59
β Herculis	K0	2.81	0.48	0.40
β Aquilae	K0	3.9	0.30	0.69
β Cygni, A	K0p	3.24	0.50	0.62
ε Aquilae	K0	4.21	0.28	0.85
σ Ophiuchi	K0	4.44	0.37	1.39
ζ Cygni	K0	3.4	0.51	0.73
β Ceti	K0	2.24	0.86	0.43
δ Tauri	K0	3.93	0.52	1.22
ε Tauri	K0	3.63	0.35	0.72
γ Aquilae	K2	2.80	0.58	0.48
α Arietis	K2	2.23	0.35	0.17
γ Draconis	K5	2.42	1.62	0.94
γ Sagittae	K5	3.71	0.51	0.98
κ Serpentis	K5	4.28	0.57	1.85
α Tauri	K5	1.06	6.82	1.14
27 stars	K1	2.94	1.14	0.71

Stars of Class M

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
α Scorpii	Map	1.22	1.00 cm	1.94 cm
H.R. 7676 Draconis	Ma	5.43	0.15	1.41
δ Ophiuchi	Ma	3.03	1.12	1.14
δ Sagittae	Map	3.78	0.77	1.58
7680 Aquilae	Map	6.56	0.06	1.59
λ Aquarii	Ma	3.84	1.02	2.21
φ Pegasi	Ma	5.23	0.22	1.72
υ Ceti	Ma	4.18	0.31	0.92
α Orionis	Ma	0.14	19.14	1.38
α Herculis	Mb	3.48	6.40	9.97
6543 Ophiuchi	Mb	6.66	0.11	3.20
β Pegasi	Mb	2.61	2.84	1.98
12 stars	Ma	3.85	3.46	2.42

Class N

Star	Sub-class	Mag.	Deflection	Deflection reduced to Mag. 3.0
H.R. 9004, 19 Piscium	N	5.03	0.46 cm	3.83 cm

The Society for Practical Astronomy.—The following officers of this society have been elected for the year 1916-17:

President: LATIMER J. WILSON
Secretary: HORACE C. LEVINSON
Treasurer: H. W. VROOMAN

Councilmen: FREDERICK C. LEONARD, JOHN E. MELLISH, R. BURNSIDE POTTER, A. F. KOHLMAN

Directors of the observing and other sections.

Planetary and Lunar: LATIMER J. WILSON
Solar: DAVID E. HADDEN
Spectroscopic: S. F. MAXWELL
Photographic: WILLIAM HENRY
Meteor: CHARLES P. OLIVIER
Comet: WILLIAM H. STEAVENSON
Aurorae, Zodiacal Light and Gegenschein: ALAN P. C. CRAIG
Nova Search: NELS BRUSETH
Instrument: M. THOMAS FULLAN
Practical Teaching: MARY E. BYRD

Editors:
FKEDERICK C. LEONARD
HORACE C. LEVINSON

Librarian:
S. F. MAXWELL

Professor William H. Pickering, of the Harvard College Observatory Station at Mandeville, Jamaica, who has been contributing the "Monthly Reports on Mars," will coöperate with the Director of the Planetary and Lunar Section of the S. P. A. and will take charge of all of the work and observations on Mars sent by members of the above Section, or of the Society in general. The membership of the Society consists of about 115 persons, but it is always glad to welcome any new members and every active observer who wishes to join in ranks.

Dr. Mary E. Byrd's efforts to establish an "unofficial" Section for the Practical Teaching of Astronomy in the S. P. A. resulted in the establishment, on November 18 last, by the Council, of an official Section in the Society, and in her appointment as its Director. This Section offers a correspondence course in astronomy, and is flourishing in a most encouraging manner. All persons interested in its work, particularly teachers of astronomy, are cordially invited to correspond with Dr. Byrd on the subject, and to join the Society and its teaching section. Miss Byrd's address is Route 9, Box 77, Lawrence, Kans.

The Section for Construction of Astronomical Instruments, under the direction of Professor M. Thomas Fullan, of the Alabama Polytechnic Institute, now has its work well under way. Professor Fullan has written that he has the stencils for his mimeographed sheets of instructions all ready for the machine, and that the sheets will be sent out to members of the section, who expect to undertake the construction of their own telescopes, shortly after the first of January.

CONSTELLAR MOVIES.

One might suppose, at daylight's close, when stars come peeping thru
And seeming countless million orbs are blinking down at you,
That yon vast galaxy of suns were painted on a screen
And some mechanical device, somewhere behind the scene,
This panorama thru the sky moved steadily and slow,
With endless and untiring zeal, for watchers here below;
We train our lorgnettes on the scene and gaze to heart's content,
Awe-struck in profound reverence, and filled with wonderment;
We watch the Great Bear "loop the loop" around the Polar Sun,
While close Canes Venatici to Boötes' heels run;
The Little Dipper makes a "swoop" and skims the Arctic seas,
As Draco winds his coils about the feet of Hercules;
The Eagle of Aquila soars above Cygnus, the Swan,
And Berenices combs her hair a la Triangulum;
Miss Libra does a "balance all", Corona Borealis
Is wont to wear the "Northern Crown", Uranographers will tell us;
Monoceros, the Unicorn, with Crater quaffs the Po,
The Dog Stars at Columba bark, that sails above Argo;
Equuleus, to catch Pisces, with Musca baits his line,
The Dolphin trips Aquarius and spills his jar of wine;
Andromeda, the chained Queen, for Perseus shows her love,
Cassiopeia sits and frowns from her chair far above;
Proud Cepheus would a Monarch be; Lacerta does not care,
Sagittae wounds Vulpecula, but missed Pegasus' Square;
Camelopardus and Lynx Aries "points" defy,
And Cetus "sounds" (for he's a whale) as Taurus charges by;
Auriga's "kids" are out all night, as Gemini's Twins are.
Behold, Orion, with his club, drives Lepus to his lair;
Sly Cancer would "crab" Hydra's act, but Leo he butts in,
Virgo holds Corvus; Indus goes to bag the Serpent's skin;
Lupus encharmed by Lyra's harp, proposes to Pavo,
Volans takes wings and thus escapes a sting from Scorpio;
Old Ophiuchus, Scutum "shields" from Sagittarius,
But Piscis Australis falls prey to long-neck greedy Grus.
Betwixt Cancer and Capricorn old Sol is on the fly,
Projecting Zodiacal views—the "movies of the sky."

L. BERTON WILLSON.

Plenty of Space.

Penman—What's your brother doing now?
Wright—Oh, he's a space writer.
"Space writer?"
"Yes he's writing up astronomy."—
Yonkers Statesman.